United States Patent [19]

Muller et al.

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[45] **Date of Patent: Jun. 4, 1991**

[54] **TOOL FOR TREATING SUBTERRANEAN WELLS**

[75] Inventors: **Laurent Muller**, Sugar Land; **Ervin Randermann**, Beasley, both of Tex.

[73] Assignee: **Dowell Schlumberger Incorporated**, Tulsa, Okla.

[21] Appl. No.: **447,869**

[22] Filed: **Dec. 8, 1989**

Related U.S. Application Data

[62] Division of Ser. No. 282,437, Dec. 9, 1988, abandoned.

[51] **Int. Cl.**[5] **E21B 33/24**; E21B 33/27; E21B 34/12

[52] **U.S. Cl.** **166/187**; 166/250; 166/334

[58] **Field of Search** 166/250, 373, 386, 387, 166/187, 332, 334, 278

[56] **References Cited**

U.S. PATENT DOCUMENTS

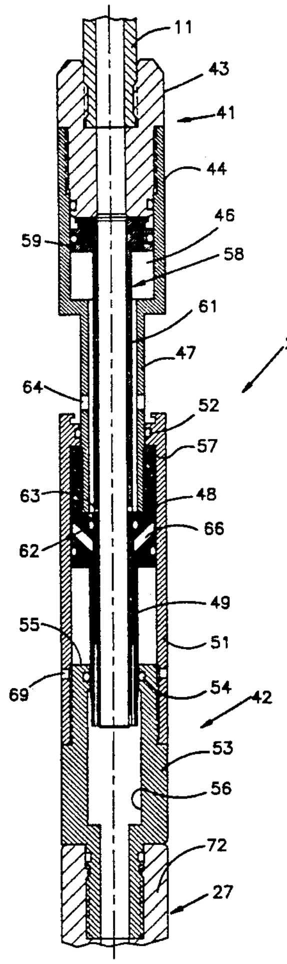
3,627,046	12/1971	Miller et al.	166/278
4,286,661	9/1981	Gazda	166/316
4,579,174	4/1986	Barrington	166/64
4,585,061	4/1986	Lyons, Jr., et al. .	
4,653,588	3/1987	White	166/187 X
4,671,352	6/1987	Magee, Jr., et al.	166/186
4,694,908	9/1987	Morris et al.	166/310
4,711,301	12/1987	Stringfellow	166/187
4,776,396	10/1988	Studholme	166/187
4,869,324	9/1989	Holder	166/387

Primary Examiner—William P. Neuder
Attorney, Agent, or Firm—Stephen A. Littlefield

[57] **ABSTRACT**

A method and apparatus for treating subterranean wells includes a tool supported on a one-piece support tube which operates to raise and lower the tool in the well to a position where well treatment is required. The tool provides inflatable packers and a selector valve operable in a first position to inflate or deflate the packers, in a second position to circulate fluid to spot treatment fluid at the tool, and a third position for injecting treatment fluid into the strata isolated from the remainder of the well by the packers. The tool provides a J-lock system and a time delay dashpot which cooperate to permit an operator at the well head to selectively operate the valve between the three positions solely by adjusting the weight on the support tube at the well head.

9 Claims, 15 Drawing Sheets



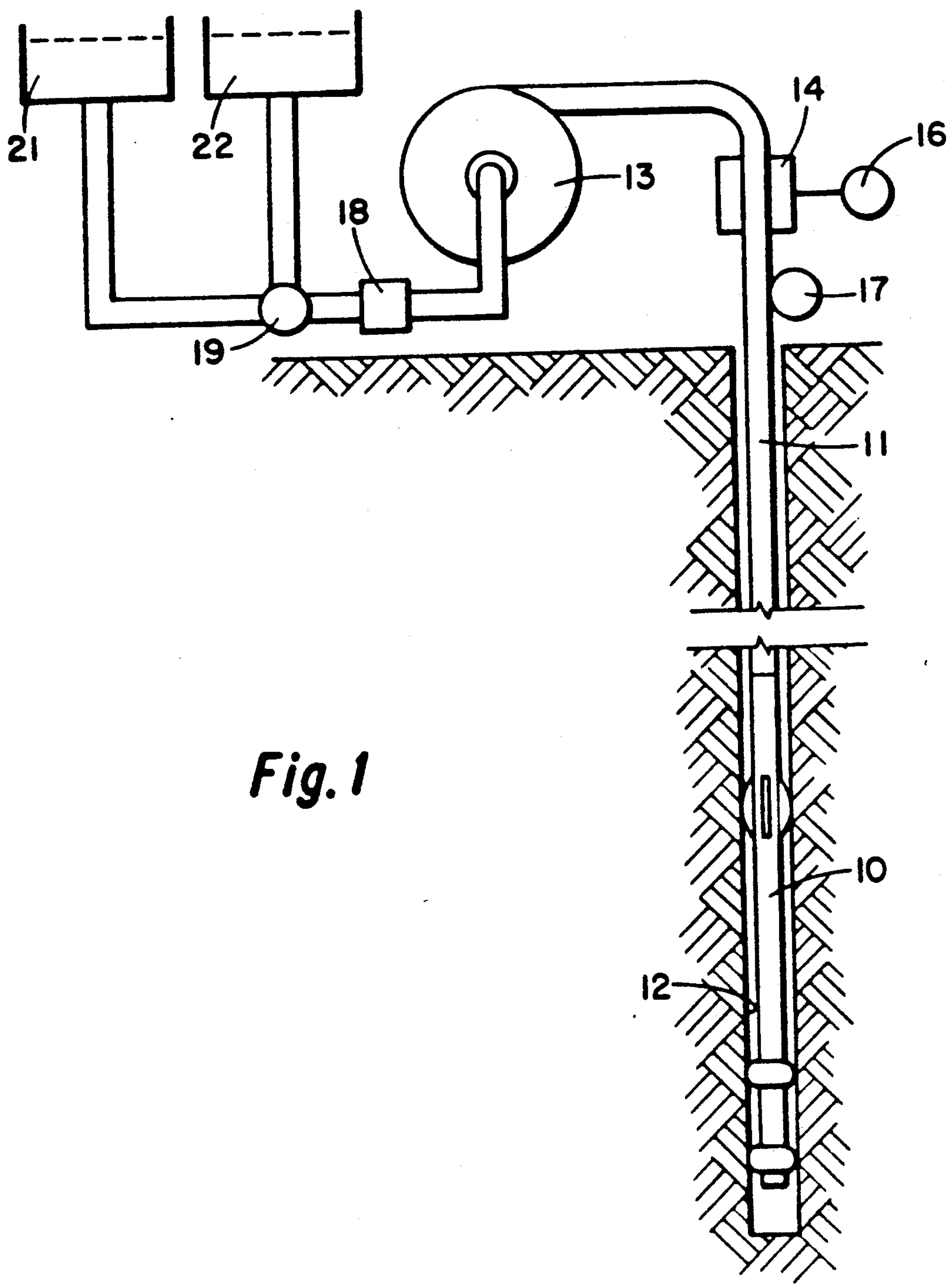


Fig. 1

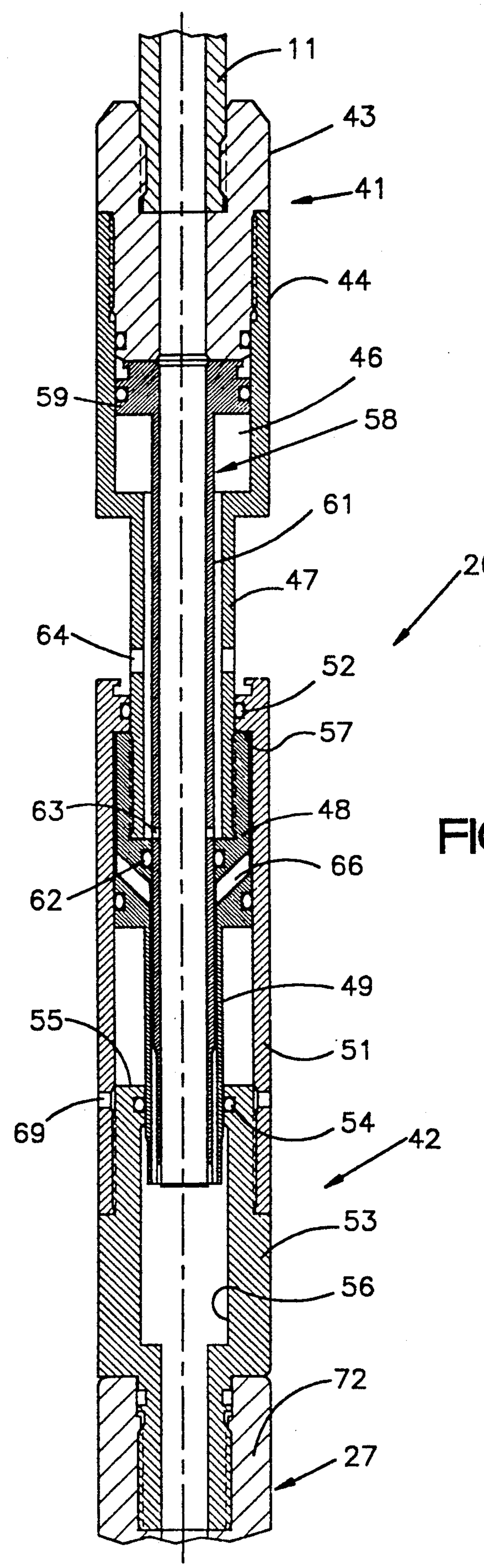

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FIG.2

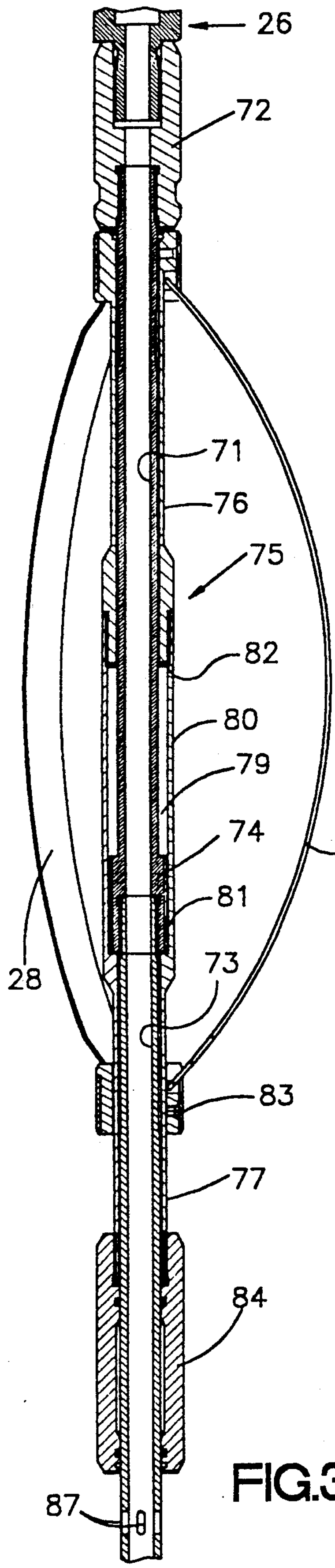
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FIG.3

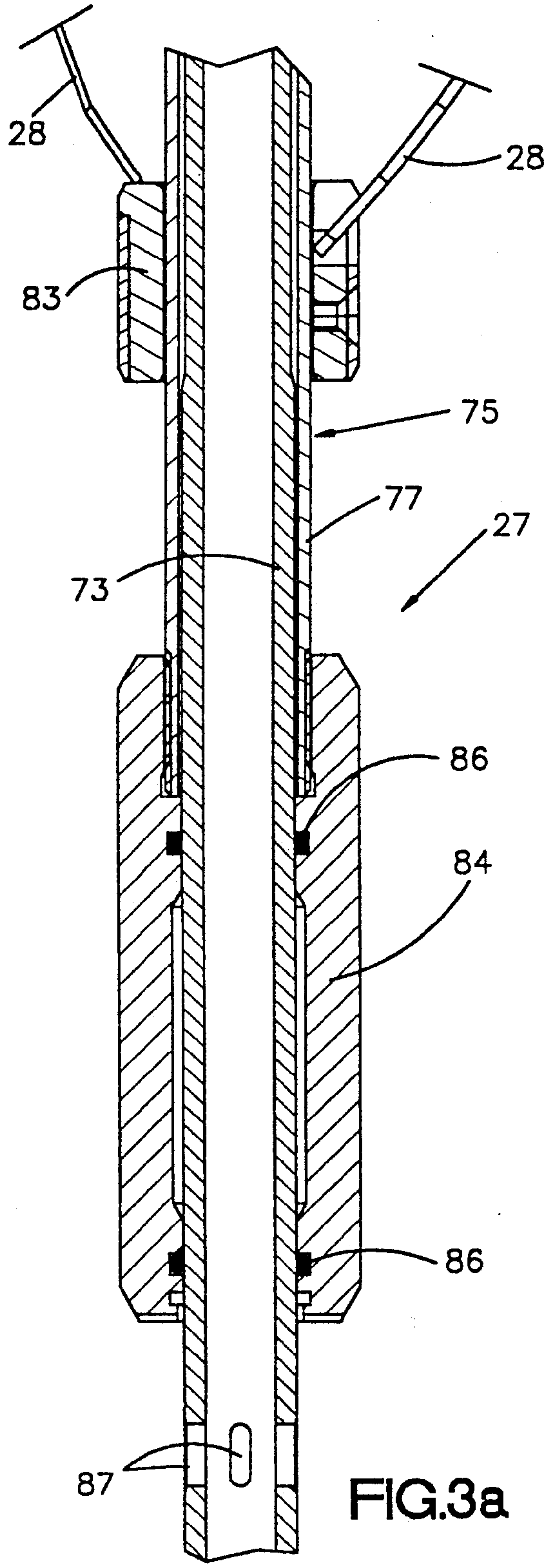
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FIG.3a

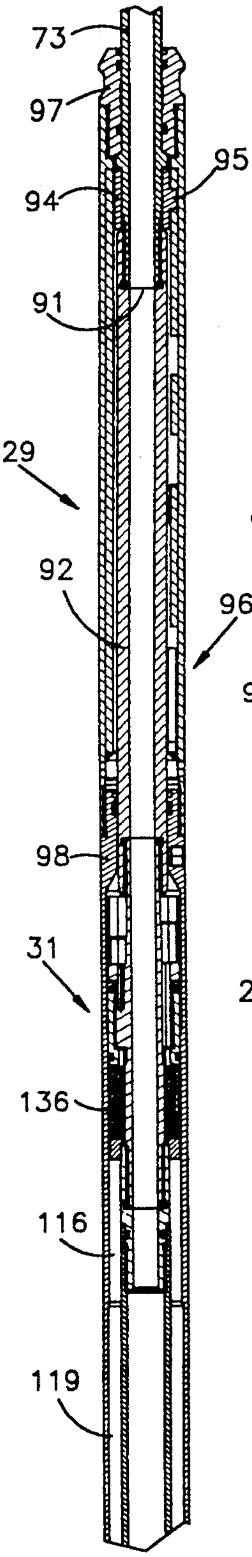

FIG.4

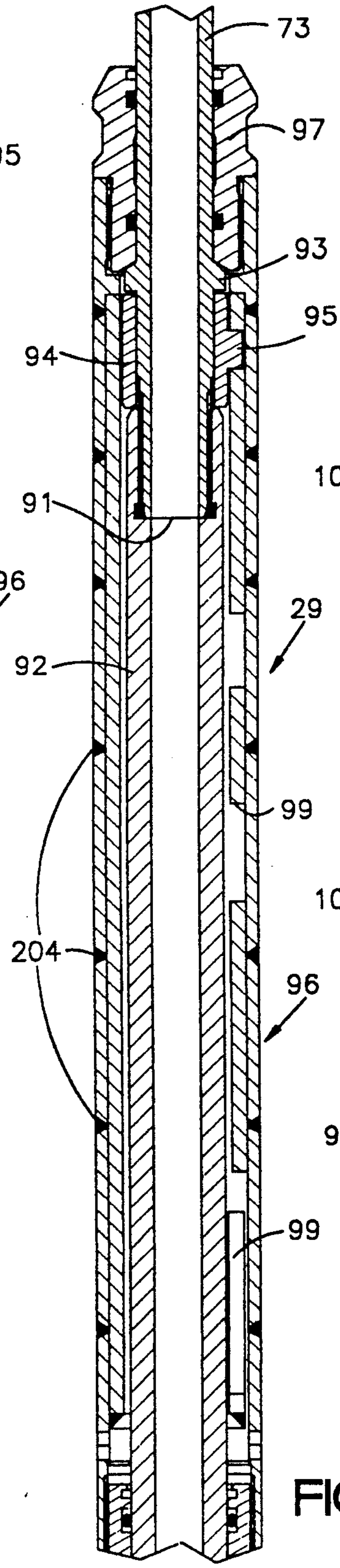

FIG.4a

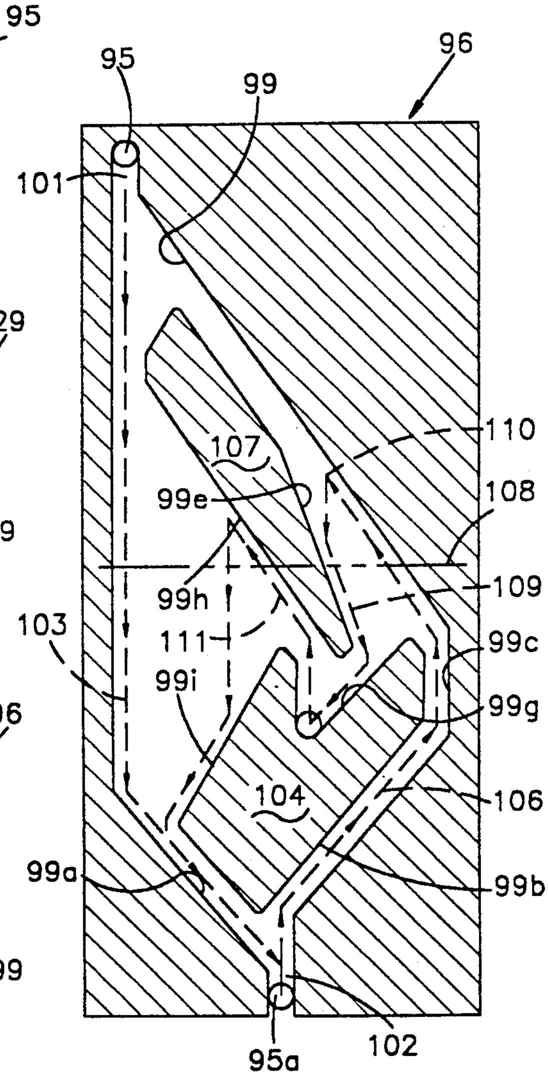

FIG.4b

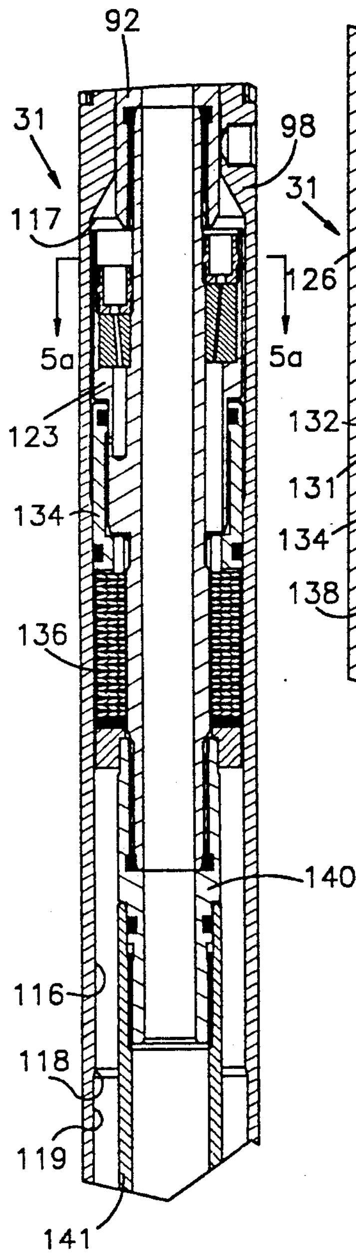

FIG.5

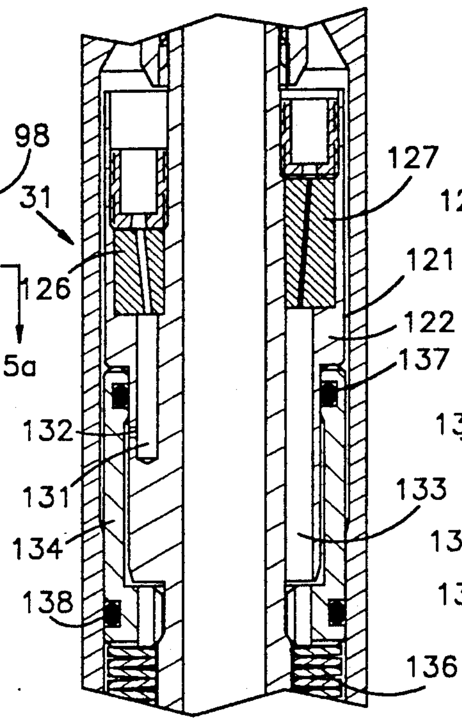

FIG.5b

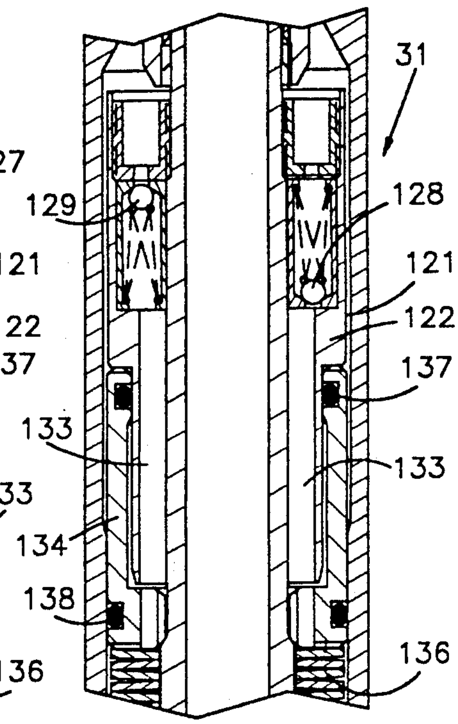

FIG.5c

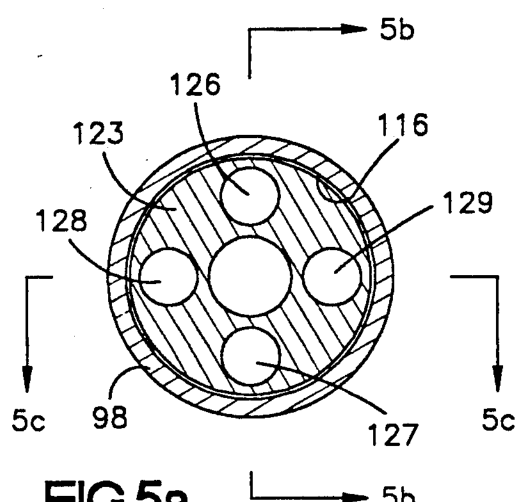

FIG.5a

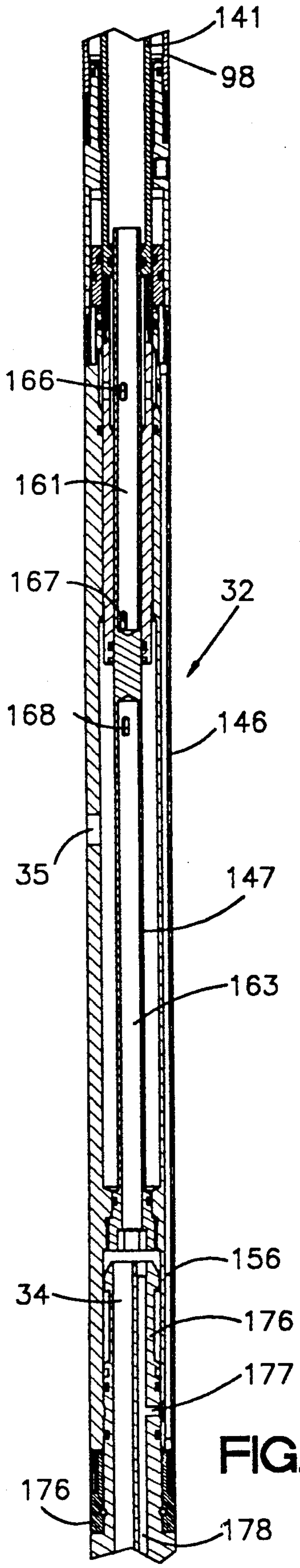
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FIG.6

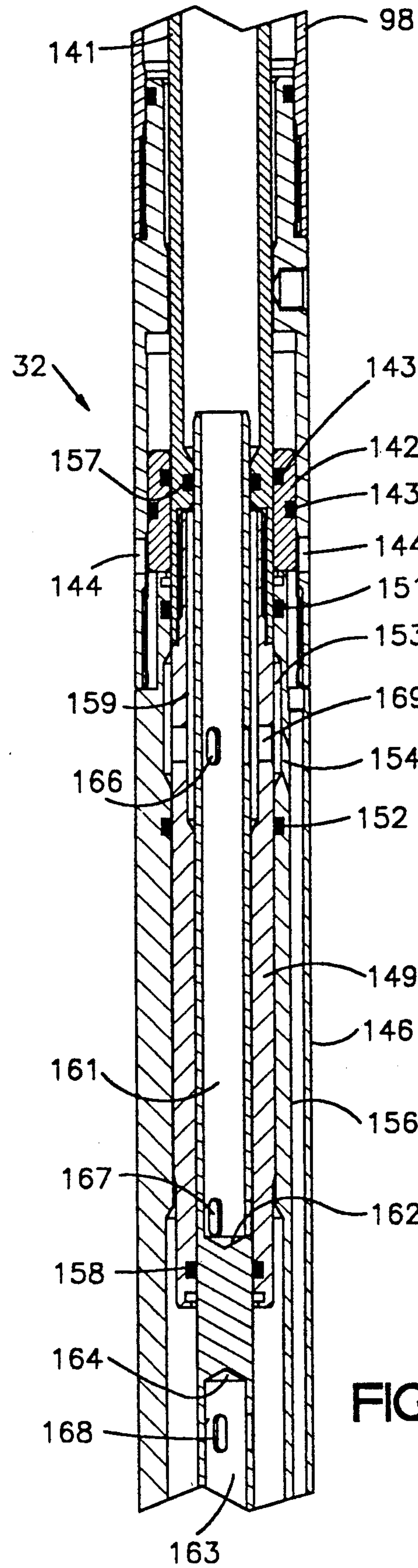
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FIG.6a

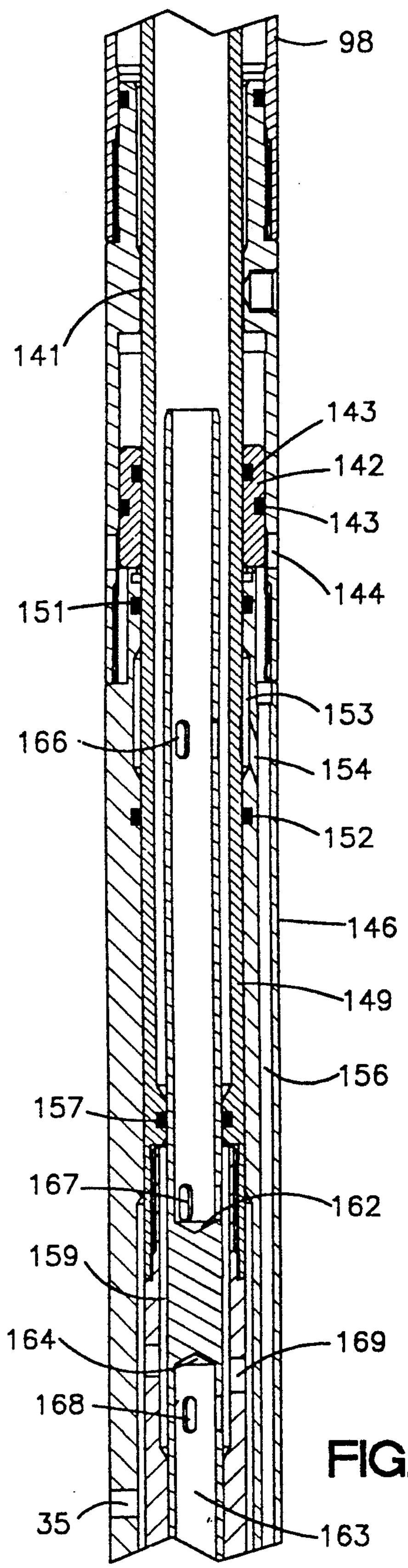
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FIG.6b

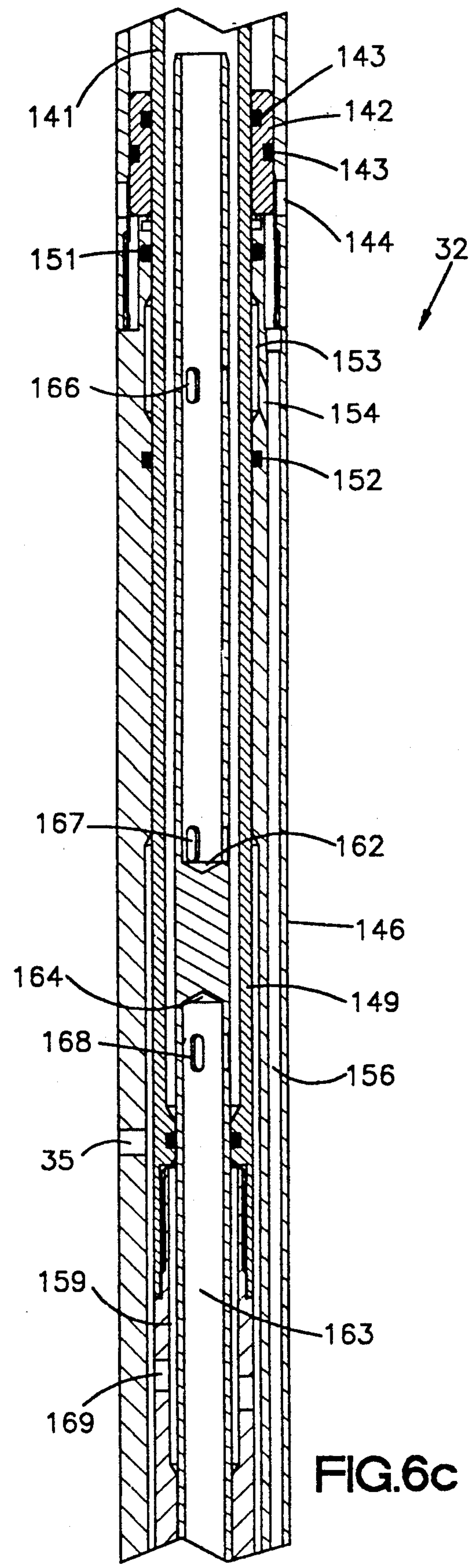
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FIG.6c

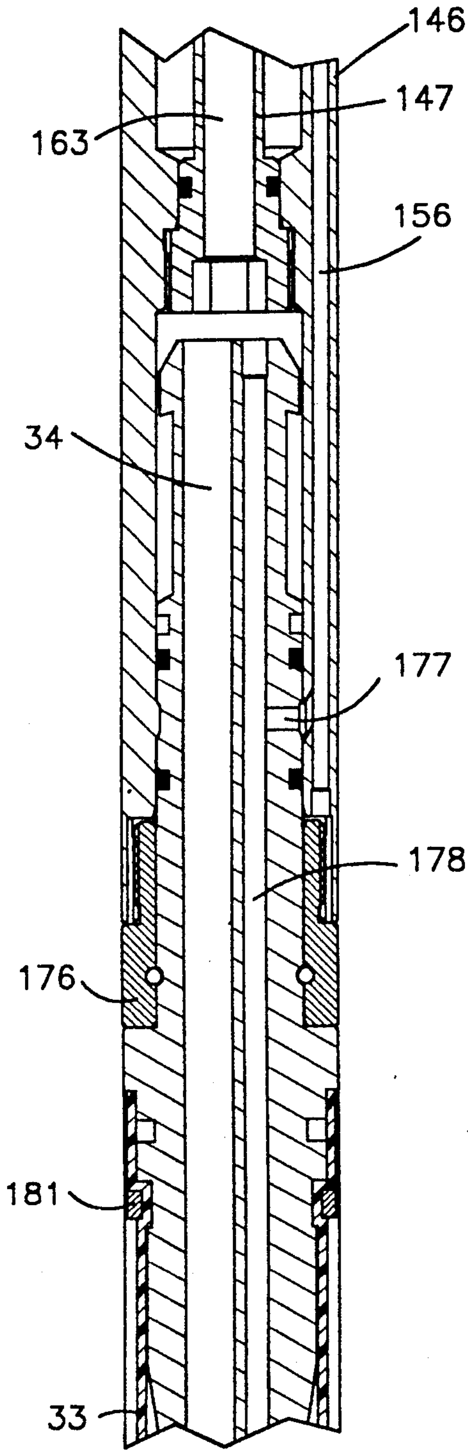
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FIG.7

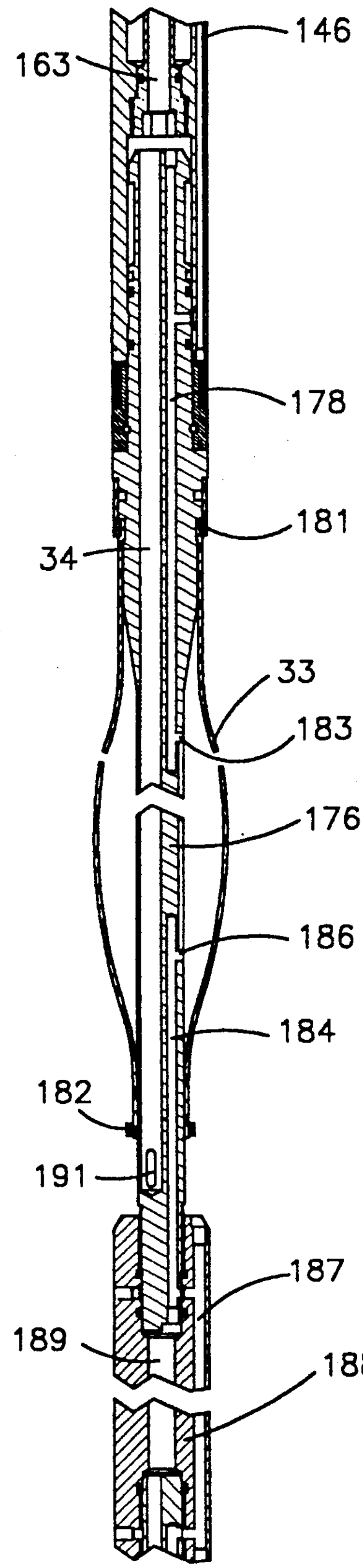
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FIG.8

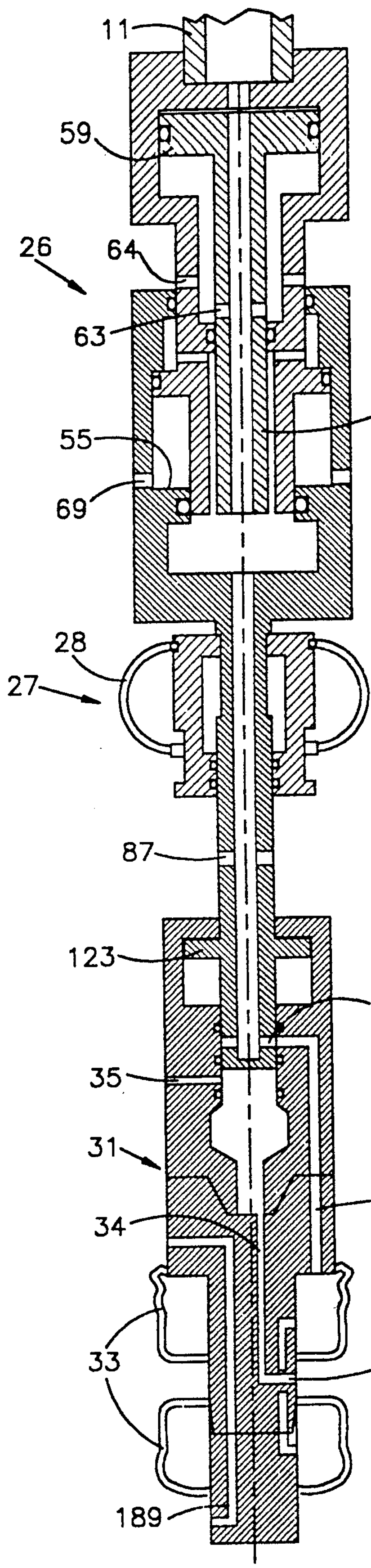

FIG.9

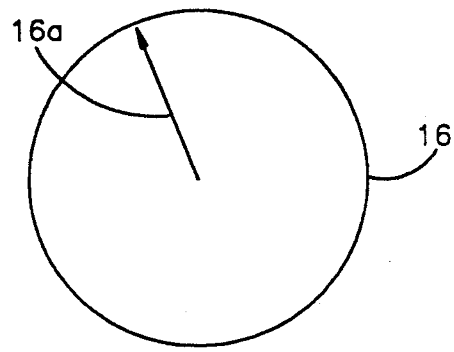

FIG.9b

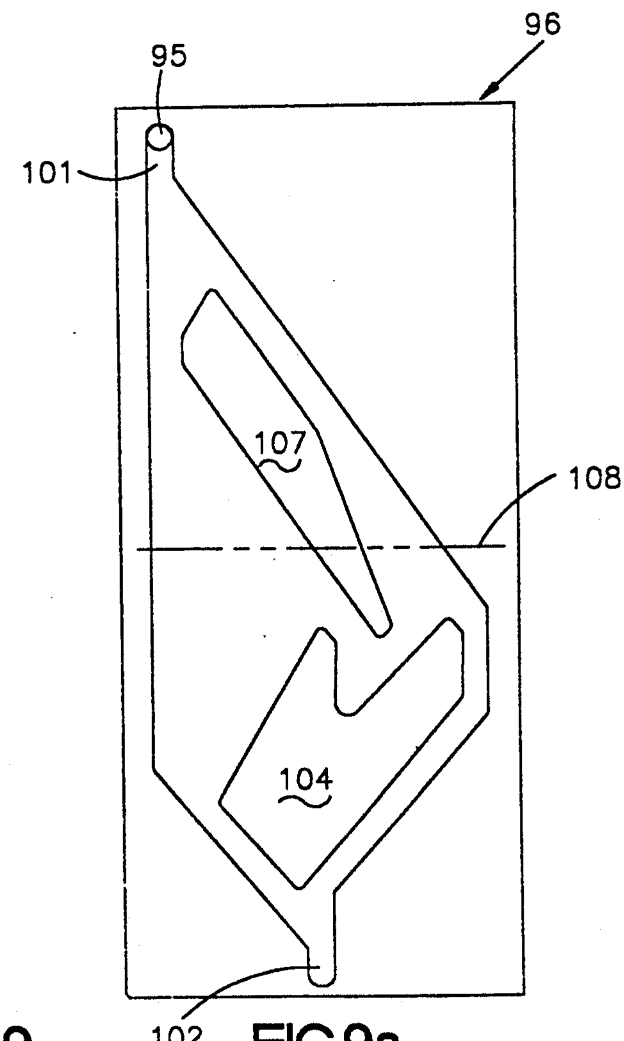

FIG.9a

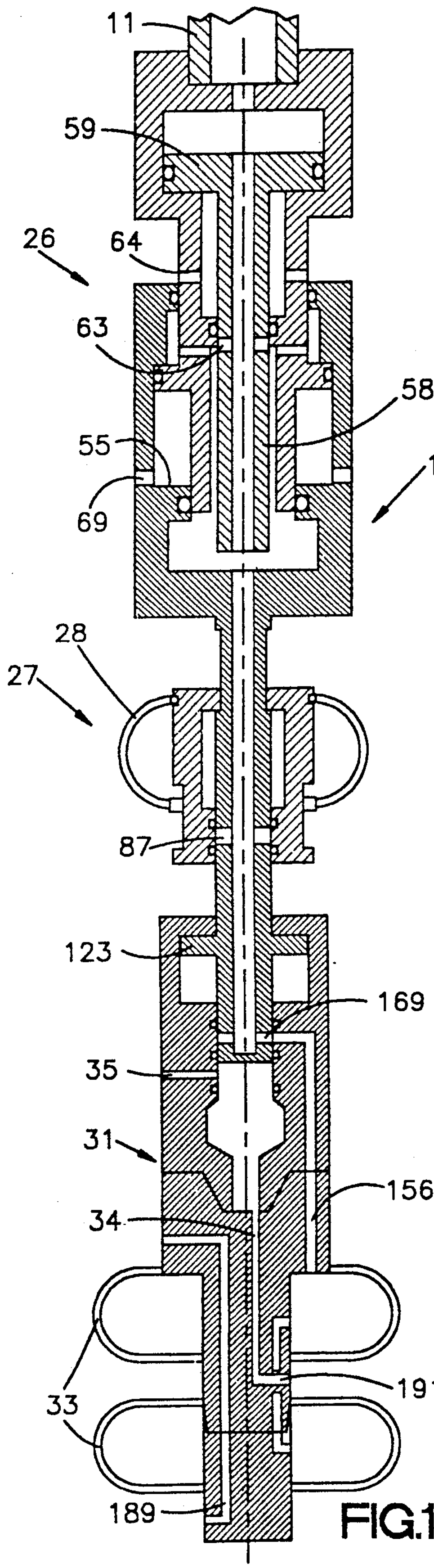

FIG.10

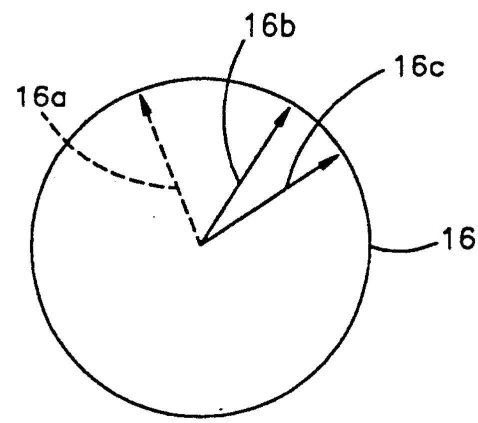

FIG.10b

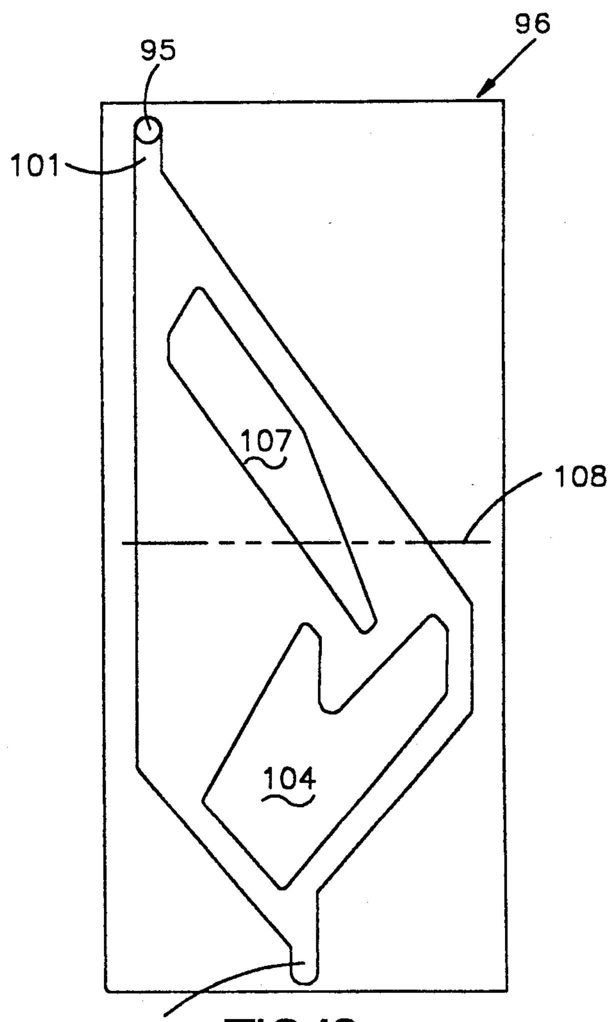

FIG.10a

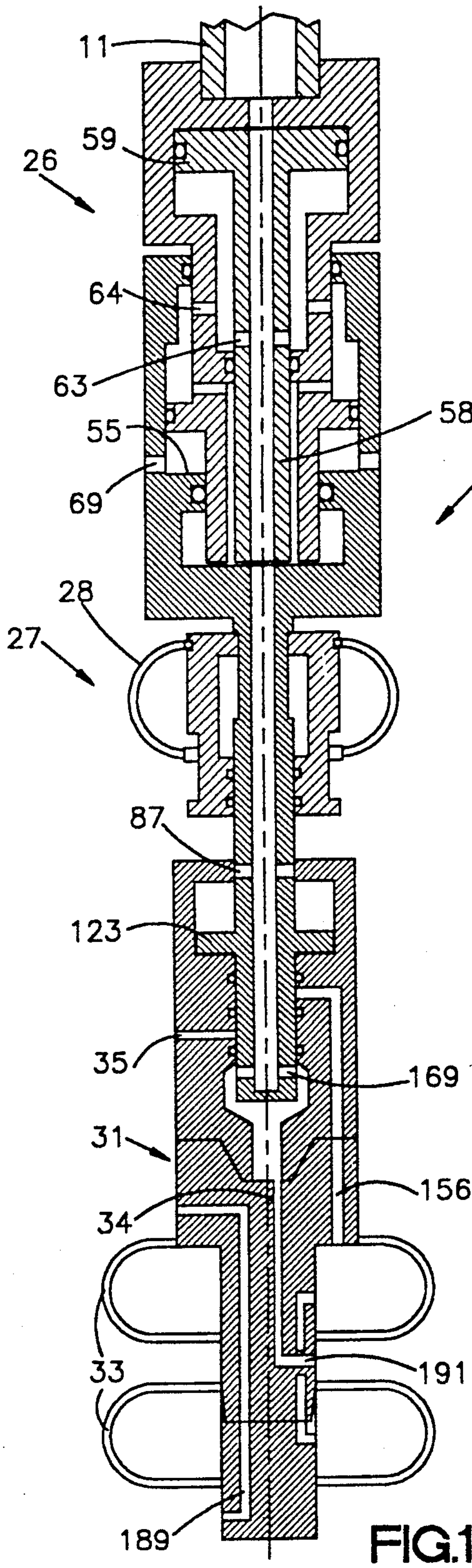

FIG.11

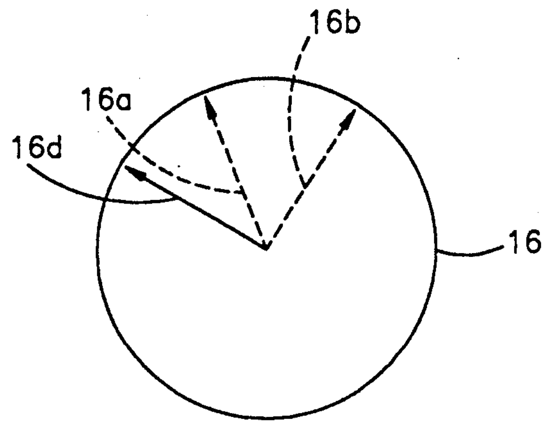

FIG.11b

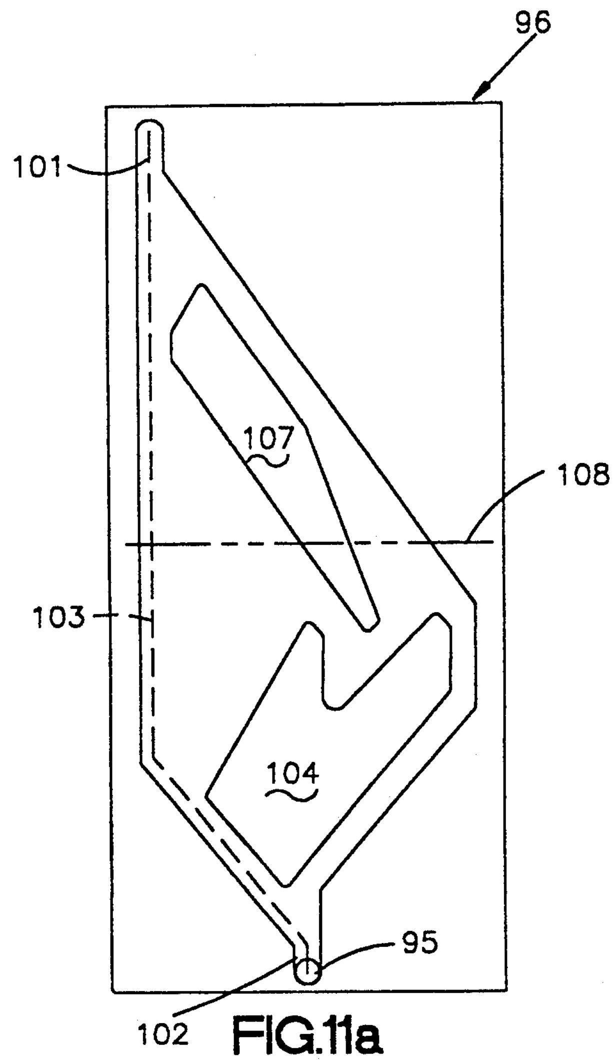

FIG.11a

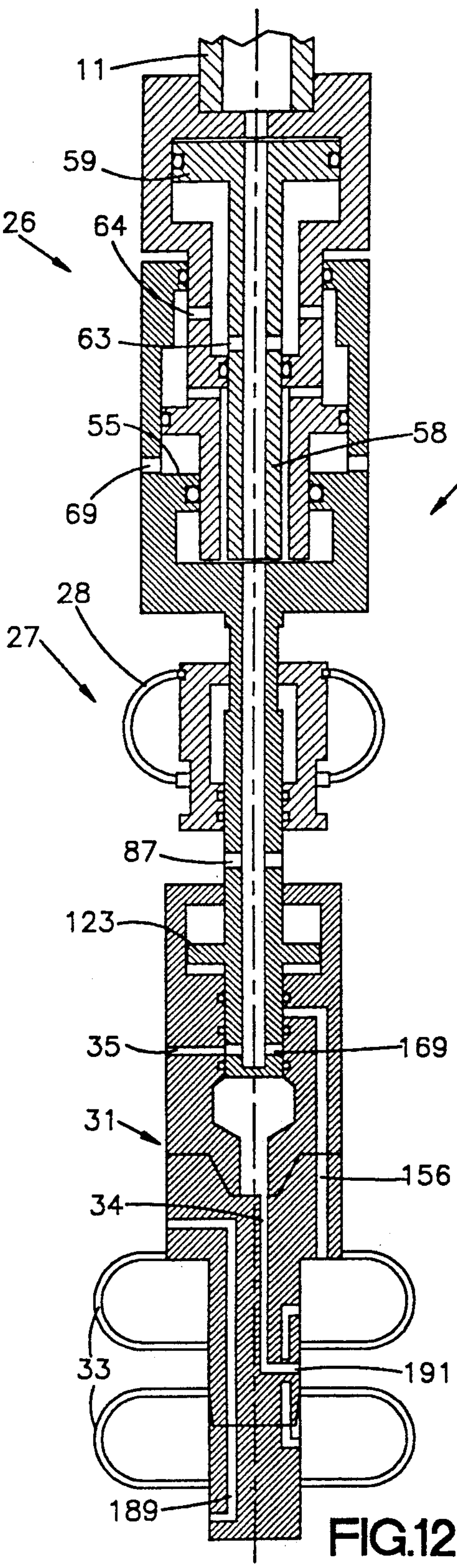

FIG.12

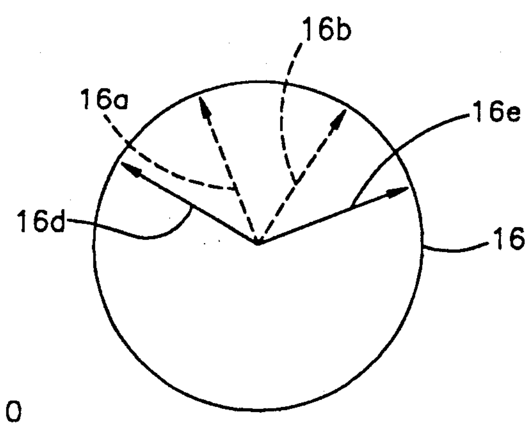

FIG.12b

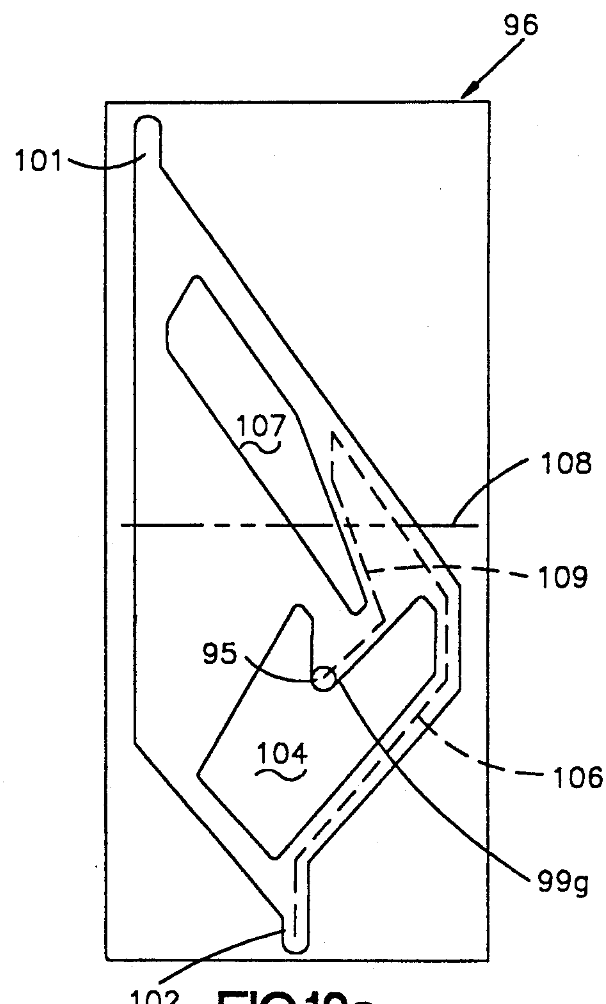

FIG.12a

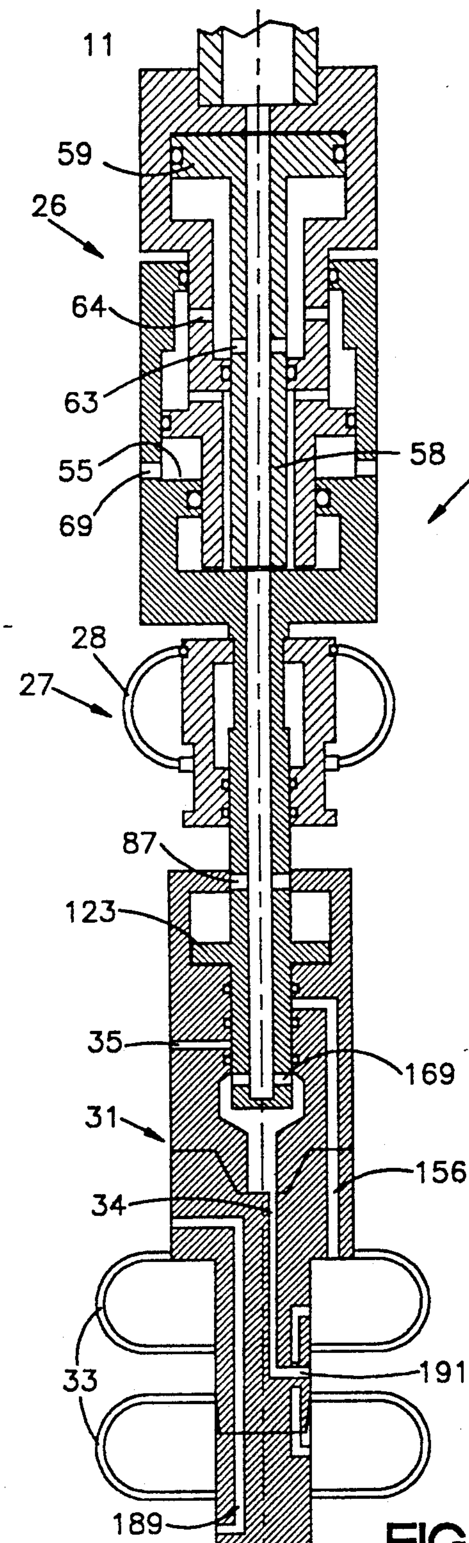

FIG.13

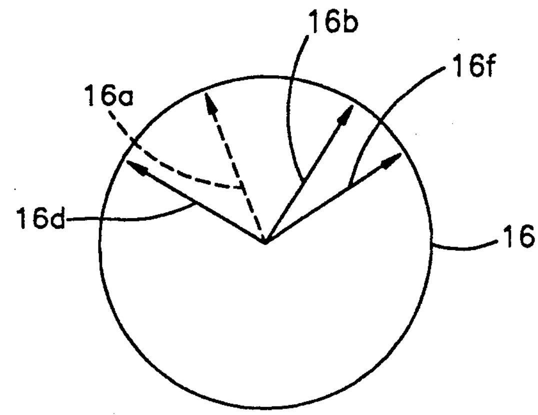

FIG.13b

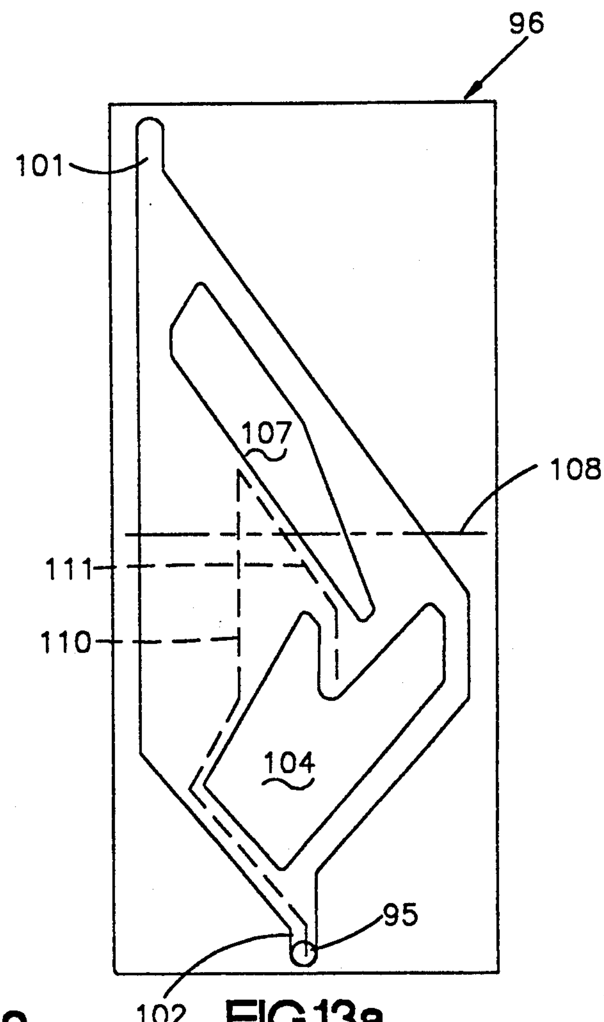

FIG.13a

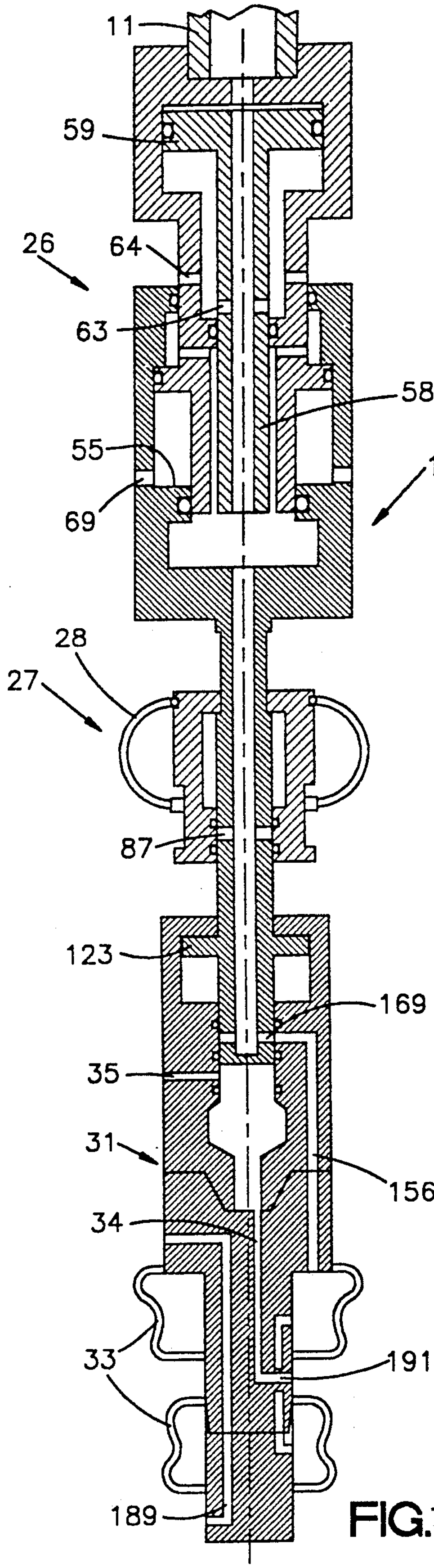

FIG.14

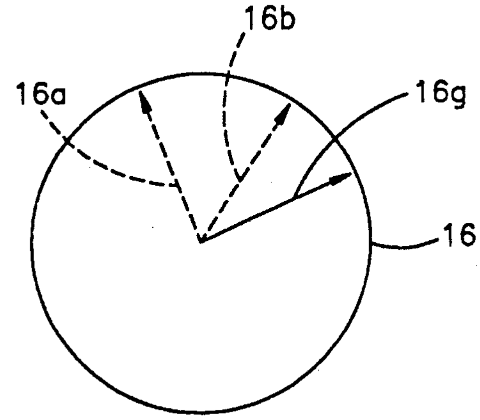

FIG.14b

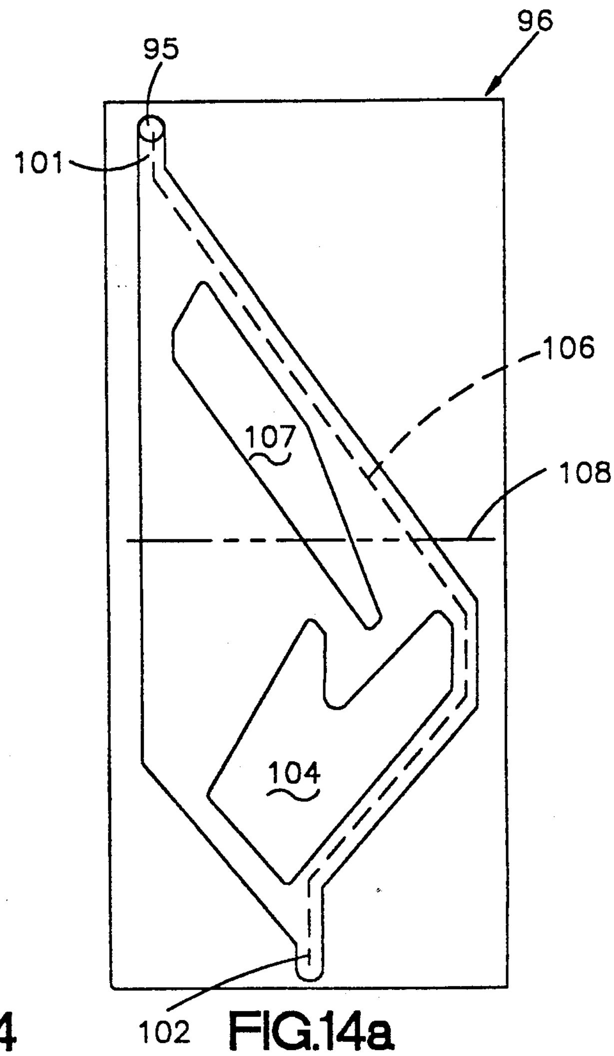

FIG.14a

Fig. 15

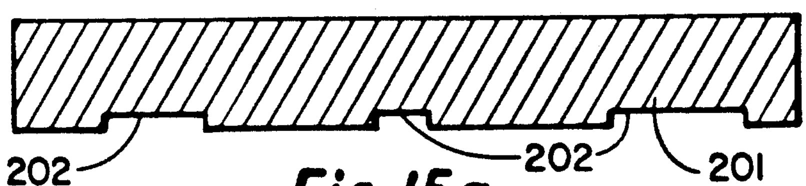

Fig. 15a

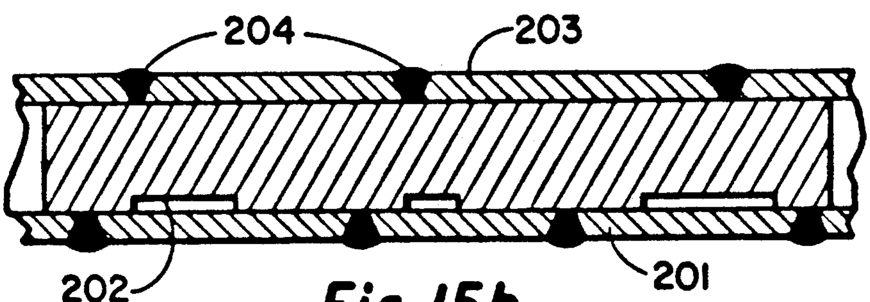

Fig. 15b

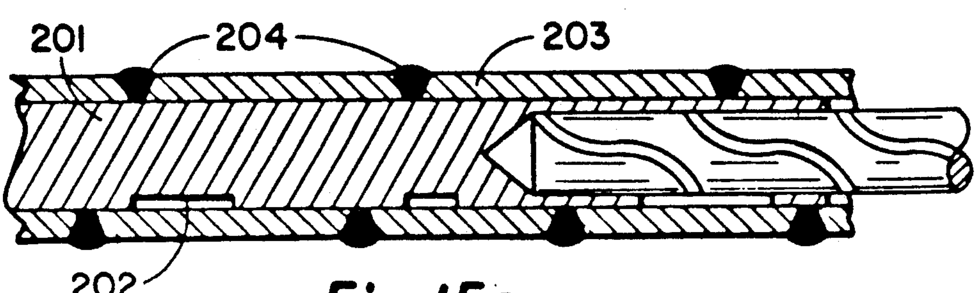

Fig. 15c

TOOL FOR TREATING SUBTERRANEAN WELLS

This is a division of application Ser. No. 07/282,437, filed Dec. 9, 1988 now abandoned.

BACKGROUND OF THE INVENTION

This invention relates generally to the treatment of subterranean wells and the like, and more particularly to a novel and improved tool for the treatment of wells particularly suited for use with one-piece coiled support tubing.

PRIOR ART

It is known to provide continuous lengths of coiled tubing to support tools within subterranean wells, and through which various fluids may be pumped to a tool mounted on the end of the coil. U.S. Pat. No. 4,585,061 discloses a system for inserting and withdrawing such coiled tubing with respect to a well. Such patent is incorporated herein in its entirety to describe such a system.

Since such tubing is a single, continuous tube, it cannot be rotated and can only be raised and lowered. Therefore, if such tubing is used to position a treatment tool within a well, rotary movement cannot be used to control the various functions of the tool. Consequently, it is difficult to employ such tubing with a tool such as a straddle packer tool or the like for the treatment of wells.

SUMMARY OF THE INVENTION

It is one important aspect of this invention to provide a method and apparatus in which a treatment tool is sequenced in its operation through a full treatment cycle by merely adjusting the load on the grippers which raise or lower a one-piece tool support tube at the well head. Further, the load on the grippers establishes that the tool has been properly cycled.

In accordance with another aspect of this invention, a novel and improved time delay selector valve is provided which can be operated from a remote location by adjusting tension in a support tube. Further, a novel and improved equalizer valve is provided.

In accordance with still another aspect of this invention, a novel and improved method is provided to form cam surfaces on the interior of a tube which may be relatively small in diameter and relatively long.

In normal operation of the illustrated embodiment of this invention, the tool packers are first positioned while deflated at the location within the well where treatment is desired. By properly sequencing changes in the pull on the tube, valves within the tool are moved to sequence the tool operation. In the illustrated embodiment, straddle packers are provided which, when inflated, isolate the portion of the well between the packers from the remainder of the well.

By adjusting the load on the tubing, the valves within the tool are sequentially operated to:

(1) provide inflation of the packers;

(2) provide an injection test to determine if the fluid can be injected into the sealed-off portion of the well;

(3) provide circulation to displace the non-treatment fluid from the tube and spot the treatment fluid at the tool;

(4) inject the treatment fluid into the strata of the well between the packers; and

(5) after treatment is completed, deflate the packers, allowing the tool to be repositioned at another treatment location, or removed from the well.

The tool is often located many thousands of feet down the well. Therefore, the supporting tubing is long and quite heavy. Because of stretch in the tubing and the like, movement of the tube at the surface of the well, either up or down, does not necessarily produce a corresponding movement of the tool. Therefore, the sequencing of the valves in the tool is controlled by selectively changing the pull or load on the tube at the surface. This provides the operator with an accurate indication of the operation of the valves to permit the operator to control the sequence of operations of the tool.

In the illustrated embodiment, the tool is provided with three interrelated valves. A drag valve is provided with drag springs which engage the well surface. When the tool is being lowered into the well, this drag valve remains open; however, raising the tool causes the valve to move to its closed position. A time delay sequencing valve is also provided. The sequencing valve provides a dashpot or damper which causes a time delay when the valve is moved in one direction. The sequencing valve also provides a J-lock cam system, permitting the positioning of the sequencing valve in an intermediate position for circulation or spotting. The three-position sequencing valve is also controlled by adjusting the load at the surface. The third valve is an equalizer valve and is also operated at the surface by adjusting the support tubing load.

With this invention, a reliable mechanical treatment tool is provided which is sequenced in its operation without rotation of the supporting tube and which can be used to perform multiple treatment sequences at various locations in the well without being removed from the well.

Also in the illustrated embodiment, the required J-lock internal camming surfaces are formed by a novel and improved method. These camming surfaces are cut in the outer surface of a cylindrical mandrel. The mandrel is then positioned within an outer tube and is button-welded to an outer tube through holes formed in the tube. The center of the mandrel is then bored out, leaving only the camming surfaces which are secured to the outer tube by the button welds.

These and other aspects of this invention are illustrated in the accompanying drawings, and are more fully disclosed in the following specification.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic representation of an entire well treatment system in accordance with the present invention;

FIG. **2** is a fragmentary, enlarged, longitudinal section, taken at the upper end of the tool and illustrating the equalizing valve provided by the tool;

FIG. **3** is a fragmentary, longitudinal cross section of a portion of the tool immediately below the equalizing valve illustrated in FIG. **2** and illustrating the drag valve portion of the tool;

FIG. **3*a*** is an enlarged, fragmentary, longitudinal section illustrating the structural detail of the valve portion of the drag valve;

FIG. **4** is a fragmentary, longitudinal section illustrating a portion of the tool immediately below the drag valve illustrated n **3**, which includes a J-lock assembly and a dashpot or time delay assembly:

FIG. 4a is an enlarged, fragmentary, longitudinal section of the J-lock assembly;

FIG. 4b is a rolled-out view of the J-lock cam structure as it would appear when viewed from the longitudinal centerline of the tool;

FIG. 5 is an enlarged, fragmentary, longitudinal section of the portion of the tool including the time delay or dashpot assembly;

FIG. 5a is a cross section taken along line 5a—5a of FIG. 5;

FIG. 5b is an enlarged, fragmentary section taken along line 5b—5b of FIG. 5a, illustrating the flow control orifices;

FIG. 5c is an enlarged, fragmentary section taken along line 5c—5c of FIG. 5a, illustrating the back check valve and pressure relief valve;

FIG. 6 is a fragmentary, longitudinal section of the selector valve in the run-in position in which the packers are inflated or deflated;

FIG. 6a is an enlarged, fragmentary, longitudinal section of a portion of the selector valve illustrating the structural detail thereof;

FIG. 6b is an enlarged, fragmentary section similar to FIG. 6a, but illustrating the selector valve in the spotting or circulating position;

FIG. 6c is an enlarged, fragmentary section similar to FIGS. 6a and 6b, but illustrating the selector valve in the injection position;

FIG. 7 is an enlarged, fragmentary section illustrating the connection of the packer subassembly to the selector valve;

FIG. 8 is a longitudinal section of a portion of the packer subassembly, illustrating one of the two spaced packers;

FIGS. 9 through 14 are schematic illustrations of the tool as it is progressively operated through one complete cycle of operation of injecting treatment fluid into a selected strata of a well;

FIG. 9 schematically illustrates the tool in the run-in position;

FIG. 9a schematically illustrates the condition of the J-lock assembly during run-in;

FIG. 9b illustrates the string weight provided by the weighing scale during run-in;

FIG. 10 schematically illustrates the tool in the packer inflation condition, and FIGS. 10a and 10b illustrate the J-lock assembly position and weight scale reading corresponding to the condition of FIG. 10;

FIG. 11 schematically illustrates the tool in the injection test position, and FIGS. 11a and 11b illustrate the corresponding J-lock assembly position and the weight scale reading;

FIG. 12 schematically illustrates the tool in the spotting or circulating position, and FIGS. 12a and 12b correspondingly illustrate the J-lock assembly and weight scale reading;

FIG. 13 schematically illustrates the tool in the injecting position, and FIGS. 13a and 13b illustrate the corresponding condition of the J-lock assembly and the weight scale reading;

FIG. 14 schematically illustrates the tool in the deflation position, and FIGS. 14a and 14b correspondingly illustrate the J-lock assembly and the weight scale reading; and

FIGS. 15 through 15c schematically illustrate the production of the internal camming surfaces provided by the J-lock assembly.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. 1 schematically illustrates the entire well treatment system in accordance with the present invention. The system includes a treatment tool 10 connected to one end of a one-piece, flexible tube 11 which functions to position the tool 10 at a desired location in a well 12. The tube 11 also functions to supply fluid to the tool 10. The tool in accordance with the present invention is particularly suited for use with one-piece support tubing because it does not require rotation for its operation. However, the tool can also be used with support tubes consisting of connected tubing sections.

The opposite end of the tube is coiled and stored on a drum 13 and passes from the drum 13 through powered grippers 14 which function to control the extension or retraction of the tube to raise and lower the tool 10 within the well 12. Connected to the grippers 14 is a weight measuring scale 16 which permits the operator to determine the weight of the tube 11 and the tool 10 being supported by the grippers 14 at any given time.

When the string, consisting of the tube and the tool, is being lowered into the well 12, the frictional drag of the string along the surface of the well reduces the load supported by the grippers 14 and provides a run-in weight. When the string is being raised, the frictional drag increases the tension in the tube and provides a pull-up weight or lifting weight. These weight differences are recorded by the operator when the tool is positioned for treatment, and are utilized in the control of the tool, as discussed below.

In addition, the system includes a measuring device 17 which engages the surface of the tube and provides the operator with an indication of the length of the string, and consequently an indication of the position of the tool within the well. Reference should be made to U.S. Pat. No. 4,585,061, supra, incorporated herein by reference, for a detailed description of a typical system for controlling the raising and lowering of the string within the well.

In addition, the system includes a pump 18 connected through a valve 19 to selectively connect the valve to a reservoir of inflation fluid 21 or a reservoir of treatment fluid 22. The output of the pump is connected to the end of the tube 11 on the drum 13, so that either inflation fluid or treatment fluid can be pumped down the tube 11 to the tool 10, as described below.

Because the tool is often lowered very great distances down a well, and because the tube 11 tends to stretch or contract when the tension therein is changed, the tool 10 in accordance with the present invention is sequenced through its various operating conditions based upon adjusted loads on the grippers 14 as indicated by the weight scale 16. The control of the tool does not require rotary control movement, and is not affected by variations in the stretch of the tube 11 extending along the length of the well 12.

FIGS. 2 through 6 are fragmentary sections which cooperate to illustrate the entire tool 10 in accordance with this invention. These fragmentary sections are taken from the top of the tool at progressive intervals along the length of the tool, with FIG. 2 illustrating the upper portion of the tool. FIG. 3 illustrating the next portion of the tool, and FIGS. 4 through 6 illustrating progressively lower portions of the tool.

FIG. 2 illustrates an equalizing valve assembly 26 which functions during the deflation portion of the cycle of the tool operation to relieve the pressure within the tool and equalizes the internal pressure with the environmental pressure surrounding the tool. Immediately below the equalizing valve assembly **26** is a drag valve assembly **27** illustrated in FIGS. **3** and **3***a*. The drag valve assembly **27** provides a plurality of leaf springs **28** which resiliently press against the surface of the well to provide a frictional engagement which resists movement of the drag valve with respect to the well when the tool is raised or lowered within the well.

Immediately below the drag valve assembly **27** is a J-lock cam system **29** illustrated in FIG. **4**. As described in detail below, this J-lock cam system cooperates with a time delay dashpot assembly **31**, also illustrated in FIG. **4**. An enlarged, fragmentary section of the J-lock cam assembly **29** is illustrated in FIG. **4***a* and an enlarged, fragmentary section of the time delay dashpot assembly **31** is illustrated in FIG. **5**. This time delay dashpot assembly **31** permits the operator to position the selector valve in one of three selected operating conditions, as discussed in detail below.

Positioned immediately below and connected to the time delay dashpot assembly **31** is a selector valve assembly **32**, illustrated in FIG. **6**. The selector valve assembly **32** is a three-position valve. In one position, it connects the pressure within the tool to inflatable packers **33**, one of which is illustrated in FIG. **8**. In a second position of the selector valve assembly **32**, supply pressure to the tool is connected to circulation ports **35**, as illustrated in FIG. **6***b*. In such second position, the portion of the well between the packers is also connected to the circulation port **35** to equalize the pressure of the portion of the well between the packers and the well portion above the packers. In the third position, the selector valve assembly **32** connects the supply pressure to the tool to a passage **34** (illustrated in FIG. **6**) for the injection of the treatment fluid into the strata of the well between the packers **33**.

The Equalizing Valve

The equalizing valve, best illustrated in FIG. **2**, provides an upper housing assembly **41** and a lower housing assembly **42**. The upper housing assembly is connected to the lower end of the tube **11** which supports the entire tool **10**. Normally, an adjustable pressure relief valve and a check valve (neither of which is illustrated) are provided at the lower end of the tube between the tube **11** and the upper housing assembly **41** to prevent backflow of liquid up along the tube **11** and also to protect the system from overpressurization. Since such back check valves and adjustable relief valves are known to persons skilled in the art, they are not illustrated herein.

The upper housing assembly **41** includes a tubular connector **43** threaded into the end of an elongated housing member **44** which cooperates with the connector **43** to define a cylinder chamber **46** and provides a tubular extension **47**. The lower end of the tubular extension **47** is threaded into a balancing piston **48**, which, in turn, is provided with a tubular extension **49**.

The lower housing assembly **42** includes an outer tube member **51** providing a seal **52** at its upper end engaging the outer surface of the tubular extension **47**. The lower end of the outer tube member **51** is threaded onto a tubular coupling member **53**. The tubular extension **49** of the balancing piston **48** extends through a seal **54** into a central passage **56** in the tubular member **53**. The lower end of the member **53** is threaded into an upper connector **72** of the drag valve assembly **27**.

The two housing assemblies **41** and **42** are connected for telescoping movement between an extended or run-in position in which the balancing piston **48** is in engagement with a shoulder **57** on the outer tube member and an inward telescoped position in which the balancing piston **48** engages the end **55** of the tubular member **53**.

A centrally located, tubular piston member **58** provides a piston head **59** within the cylinder chamber **46** and a tubular rod portion **61** extending through the balancing piston **48** and a seal **62** therein. In the run-in position, the friction of the seals **62** maintains the piston member **58** in the upper position in which the piston head **59** engages the lower end of the tubular connector **43**. In such position, an orifice or port **63** connects the interior of the tubular rod portion **61** to the interior of the tubular extension **47**. Further, when the two housing assemblies **41** and **42** are in their extended position, a port **64** provides communication between the interior of the tubular extension **47** and the surrounding portion of the well. Therefore, in the run-in position illustrated in FIG. **2**, fluid pumped down the tube **11** to the tool **10** is vented to the surrounding portion of the well through the ports **63** and **64**.

However, the equalizing valve **26** is structured so that when the flow of fluid into the tool exceeds a predetermined amount, such as about 0.2 barrel per minute, the equalizing valve is closed. In order to provide such closing action, the port **63** is sized to be substantially smaller than the port **64**. When the flow rate of fluid to the tool is increased, a pressure drop occurs through the port **63** which is sufficient to cause a differential pressure across the piston head **59**. This causes the piston head **59** to be moved down along the upper housing assembly **41** a sufficient distance to move the port **63** past the seal **62** in the balancing piston **48** to close the equalizing valve **26**.

The equalizing valve is also closed when the two housing assemblies **41** and **42** are telescoped together to move the port **64** past the seal **52** in the outer tubular member **51**. Movement of the two housing assemblies **41** and **42** to the closed or fully telescoped position, however, causes the lower end of the tubular rod portion **61** to engage a shoulder at the lower end of the passage **56**. This also functions to reposition the piston member **58** in its upper position within the upper housing **41** in which the port **63** is above the seals **62** and the balancing piston **48**.

The balancing piston **48** functions to prevent high pressure within the tool from extending the two housing assemblies **41** and **42**. In balancing operation, high pressure within the tool is communicated to the upper side of the balancing piston **48** through a port **66**. A port **69** maintains the lower side of the balancing piston at environmental well pressure. The high pressure on the upper side of the balancing piston produces a downward balancing force on the upper housing assembly **41**, counteracting the pressure-induced force tending to cause the upper housing assembly **41** to move up relative to the lower housing assembly **42**.

The Drag Valve

Referring now to FIGS. **3** and **3***a*, the drag valve assembly **27** includes an upper tubular member **71** threaded at its upper end into the coupler **72** which connects with the equalizing valve assembly **26**. A lower tubular member **73** is threaded into the lower end of the upper tubular member **71**. An enlarged portion **74** is provided at the lower end of the upper tubular member **71**.

Positioned around the two tubular members **71** and **73** is a sleeve assembly **75** consisting of an upper sleeve **76** and a lower sleeve **77**. The upper end of the lower sleeve **77** is provided with an enlarged portion **80** which cooperates with the end of the upper sleeve to provide a chamber **79** enclosing the enlarged portion **74**.

Mounted on the sleeve assembly **75** are a plurality of leaf springs **28** which are arched in an outward direction to provide a resilient engagement with the surface of the well **12** and produce a frictional drag with respect to the well which resists movement of the sleeve assembly with the tool as the tool moves either up or down along the well. During the run-in, the frictional drag provided by the springs **28** causes the sleeve assembly **75** to move to an upper position relative to the tool, in which the enlarged portion **74** engages a shoulder **81** in the sleeve assembly **76**. When the tool is raised, the frictional engagement between the springs **28** and the well surface resists upward movement of the sleeve assembly **75** with the tool, and the sleeve assembly assumes a lower position in which the enlarged portion **74** engages the end **82** of the upper tubular member **71**.

The lower ends of the springs **28** are mounted in a collar **83** which is slidable along the sleeve assembly **75** to permit the springs to flex in and out so that they can follow the contour of the wall of the well and maintain resilient frictional engagement therewith. The springs **28** are relatively long so that they can extend a substantial distance to engage the well casing after passing through a relatively small diameter production tube.

Threaded onto the lower end of the sleeve assembly **75** is a valve sleeve member **84** which is longitudinally movable relative to the lower tubular member **73** and provides spaced seals **86** which dynamically seal with the outer surface of the lower tubular member **73**. During the run-in of the tool, in which it is lowered into the well, the sleeve valve member is held in its upward position by the frictional engagement between the leaf springs **28** and the well surface, and in such position the lower seal **86** is above ports **87** in the lower tubular member. Therefore, the drag valve assembly **27** is in an open position, allowing circulation of liquid pumped down into the tool **10** through the tube **11**. However, if the tool is raised, the frictional engagement between the springs **28** and the well surface causes the sleeve valve member **84** to move down relative to the inner tubular members to close the ports **87**. Therefore, the drag valve is responsive to the direction of movement of the tool **10** and is open when the tool is being lowered in the well and closed when the tool is being raised.

The J-Lock Assembly

The J-lock assembly **29** is illustrated in FIGS. **4**. **4***a*, and **4***b*. FIG. **4***b* is a rolled-out view of the J-lock cam structure illustrating the cam structure as a plane as it would appear from the central longitudinal axis of the tool.

The lower tubular member **73** extends beyond the lower end of the drag valve **27** to an end **91** which is threadedly connected to an intermediate tubular member **92**. Positioned between a shoulder **93** on the tubular member **73** and the upper end of the intermediate tubular member **92** is a cam follower ring **94** which is free to rotate around the central axis of the tool but is held against axial movement relative to the tubular members **73** and **92**. The cam follower ring **94** provides a projection **95** extending radially outward from the ring.

Positioned around the tubular member **73** is a J-lock cam sleeve assembly **96** threaded into a gland ring **97** at its upper end and into a cylinder sleeve **98** at its lower end. The J-lock cam sleeve assembly **96** is axially movable along the tubular members **73** and **92** and is provided with a camming surface **99** shaped as best illustrated in FIG. **4***b*. The follower projection **95** engages the camming surface **99** and moves with the selector valve assembly between three operating positions, as described in detail below.

Referring to FIG. **4***b*, the cam surface **99** includes an upper pocket **101** and a lower pocket **102**. During the runin of the tool, the follower projection **95** is positioned in the upper pocket **101**.

The cam surfaces are shaped so that if the tubular members **73** and **92** move downwardly relative to the J-lock cam sleeve assembly **96**, the follower projection **95** moves directly down along a first path **103**, indicated by direction arrows, until it engages an inclined camming surface **99***a*, along which it moves into the pocket **102**, as indicated at **95***a*.

If the follower projection **95** is in the lower pocket **102** and the tubular members **73** and **92** are raised relative to the J-lock cam sleeve assembly **96**, the follower projection **95** engages the inclined underside **99***b* of a first island cam portion **104** along which it moves along a second path **106** As the movement continues, the follower projection moves along a vertical cam portion **99***c* into engagement with an inclined cam surface portion **99***d* and up alongside a second island cam portion **107**. The line **108** indicates the relative position between the J-lock cam sleeve assembly **96** and the tubular members **73** and **92** above which flow-restricting orifices commence to operate to resist the movement of the follower projection **95** in an upward direction. This damping or time delay function and the structure for producing it are discussed in detail below.

After passing the position indicated by the line **108** a position is reached at **110** before reaching a position in alignment with the upper end of the second island **107**. The direction of relative movement is then reversed by reducing the tension in the support tube **11**. The follower projection **95** then moves down along the upper surface **99***e* and drops into a J-lock pocket **99***g* to hold the selector valve in an intermediate position. In that position, circulation of fluid through the tool is provided, as discussed below. On the other hand, if the relative movement is not reversed, the follower projection **95** returns to the upper pocket **101**.

The movement path **109** indicates the path of the follower projection **95** to the J-lock pocket **99***g*.

Once in the J-lock pocket **99***g*, upward movement of the follower projection **95** relative to the J-lock cam sleeve assembly **96** causes the follower projection **95** to move vertically upward along the path **111** and along the underside **99***h* of the second island cam portion **107** past the position indicated by the line **108**. If such upward travel is continued, the follower projection **95** moves into the upper pocket **101**.

On the other hand, if such upward travel is reversed, the follower projection **95** moves into engagement with the inclined cam surface **99***i* and returns to the lower pocket **102**.

With this structure, the selector valve described in detail below can be moved in such a way that the valve can be moved to either extreme position from the J-lock pocket **99g** by merely timing the increased tension force applied to the support tube **11**.

The Time Delay Dashpot Assembly

The time delay dashpot assembly **31** is best illustrated in FIG. **5**, and fragmentary, enlarged sections thereof are illustrated in FIGS. **5a** through **5c**. Referring first to FIG. **5**, the cylinder sleeve **98** provides an upper cylinder portion **116** extending from the location **117** to the location **118**. Below the location **118**, which is the lower end of the upper cylinder portion **116**, the cylinder sleeve provides a second cylinder portion **119** having a diameter greater than the diameter of the upper cylinder portion **116**. The two cylinder portions **116** and **119** are filled with liquid isolated from the remainder of the tool.

Threaded onto the lower end of the intermediate tubular member **92** is a damper piston assembly **121**. Such assembly includes a tubular piston head member **122** providing a piston head portion **123**. The piston head assembly **121** is sized to fit the upper cylinder portion **116** with a close fit but providing clearance with the lower cylinder portion **119**.

As best illustrated in FIG. **5a**, the piston head portion **123** is provided with four flow control devices peripherally spaced around the piston head portion. The first flow control device **126** is a first orifice assembly. The second flow control device **127** is a second orifice assembly. A back check valve assembly **128** constitutes the third flow control device, and a pressure relief valve assembly **129** constitutes the fourth and last flow control device.

Referring now to FIG. **5b**, the first flow control device **126** is open to the lower side of the piston head portion **123** through a passage **131** and a lateral port **132**. However, the orifice assembly **127** is open through a through-passage **133**. The piston head assembly also includes a sleeve valve member **134** which is resiliently biased toward the piston head portion **123** by a set of springs **136**. In its normally extended position, the sleeve valve **134** positions a seal **137** above the lateral port **132**. Therefore, the orifice assembly **126** is open to the two sides of the piston head portion **123**. However, when the differential pressure across the sleeve valve **134** reaches a predetermined value, the force of the spring set **136** is overcome and the sleeve valve moves downwardly until the seal **137** is positioned below the port **132**. In such position, the orifice assembly **126** is closed by the cooperation of the seal **137** and the seal **138**, and further flow through the orifice assembly **126** is prevented. The seals **138** also provide the seal for the piston assembly **121** with the upper cylinder portion **116**.

The shifting of the sleeve valve **134**, however, does not affect the operation of the orifice assembly **127**. With this two-orifice structure, two rates of damping are provided. The orifice assembly **126** provides a relatively large orifice allowing relatively rapid movement of the piston assembly. However, when the sleeve valve shifts to its operating closed position, the orifice assembly **126** ceases to function and all of the flow must occur through the orifice assembly **127**. Such orifice assembly provides a smaller orifice, so the rate of movement of the piston assembly in the damping mode is quite slow, as discussed in greater detail below.

As illustrated in FIG. **5c**, the check valve assembly **128** connects the two sides of the piston to allow the piston to move downwardly in a substantially unrestricted manner. Therefore, the orifice assemblies **126** and **127** provide restricted rates of movement only in the upward direction relative to the cylinder sleeve **98**. The pressure relief valve **129** performs a safety function of allowing downward movement of the cylinder sleeve **98** relative to the piston assembly. In the event that the orifices become clogged, the pressure relief valve allows movement of the tool to a deflate position so that the tool can be retrieved.

The lower end of the piston head member **122** is threaded into the upper end of a tubular connector **140**. The connector member is also threadedly connected to a tubular valve member **141** which extends through a ring gland **142** (illustrated in FIG. **6a**) providing inner and outer seals **143**. The ring gland **142** is free to slide longitudinally through a limited distance. Ports **144** maintain the lower side of the ring gland **142** to environmental pressure. The gland functions to compensate for changes in volume of the damper liquid due to changes in pressure and temperature as the tool is lowered into the well.

When the piston head assembly **121** is located within the lower end enlarged cylinder portion **119**, clearance is provided around the piston head assembly and the piston head assembly can move freely. However, when the piston head assembly **121** enters the upper cylinder portion **116**, a dynamic seal is provided between the piston head assembly and the cylinder wall and damping or time delay is provided to prevent rapid movement of the piston head assembly up along the cylinder wall.

The Selector Valve Assembly

The selector valve assembly is best illustrated in FIGS. **6** through **6c**, and includes an outer tubular housing member **146** mounted at its upper end on the cylinder sleeve **98** and extending downwardly therefrom. A tubular inner housing member **147** is threaded at its lower end into the outer housing member **146** substantially adjacent to its lower end and cooperates with the outer housing member **146** to provide a valve housing assembly which is fixed against longitudinal movement relative to the cylinder sleeve **98**. The tubular valve member **141** and an extension valve member **149** extend between the two housing members **146** and **147** and are longitudinally movable relative thereto to perform the various valving functions required.

Spaced seals **151** and **152** on the outer housing member **146** engage the outer surface of the valve member **141** and **147** on either side of an annular chamber **153** which surrounds the valve member **141** and **147**. A port **154** connects the annular chamber **153** with a longitudinally extending passage **156** through which fluid flows to inflate and deflate the packers **33**.

When the valve member **141** is positioned as illustrated in FIG. **6a**, ports **169** in the valve member **149** are open to the annular chamber **153** and the selector valve is in the inflate/deflate position. The valve member **141** also provides a seal **157** which engages the exterior surface of the inner housing member **147** and which moves therealong when the valve is moved between its operation positions. Similarly, a seal **158** mounted adjacent to the lower end of the valve member **149** engages and provides a running seal with the outer surface of the inner housing member **147**.

Between the seal **157** and piston head assembly **121**, the valve member is sized to provide clearance with the exterior surface of the inner housing member **147**. The valve member also provides an annular chamber **159** surrounding the inner housing member **147** between the seals **157** and **158**.

The upper end of the inner housing member **147** is provided with a central passage **161** extending to an end **162**. A second longitudinal passage **163** extends up along the inner housing member to an end **164** spaced from the end **162** so that the two passages **161** and **163** are not directly connected. First ports **166** are formed in the wall of the inner housing member **147** at a location approximately midway along the length of the passage **161**. Second ports **167** also extend through the wall of the inner housing member **147** substantially adjacent to the lower end of the passage **161**. A third set of ports **168** extend through the wall of the inner housing member **147** substantially adjacent to the upper end of the passage **163**.

In the run-in position illustrated in FIG. **6***a*, the ports **169** are positioned adjacent to the annular chamber **153** and communication is provided through the ports **166**. **169**, and **154** to the inflate/deflate passage **156**. In such position, the packers can be inflated or deflated. In such position, however, the seal **158** engages the portion of the inner housing member between the ends of the two passages **161** and **163** so the remainder of the tool is isolated from the liquid pressure in the upper portion of the tool.

When the valve member **141** is moved to the circulating position illustrated in FIG. **6***b*, the port **169** is spaced from the annular chamber **153** so the packer inflate/deflate passage **156** is isolated and the packers remain inflated. In such position, the port **169** is in communication with the annular chamber **159** and fluid flow is provided thereto through the ports **168**, which are then located below the seal **157**. In such condition, fluid pumped down to the tool passes through the port **169** and through the circulation port **35** formed in the outer housing member **146**. Also in such valve position, the zone between the packers is connected to the port **35**.

The valve member **141** is also movable to a third or inject position illustrated in FIG. **6***c* in which the port **169** is isolated from the interior passage **163** by the seals **157** and **158**. However, in this position, communication is provided with the lower passage **163** through the ports **168**, which are then located above the seal **157**. The time delay selector valve is therefore operable in three different positions to perform in sequence the various operations required for the treatment of the well.

FIG. **7** is an enlarged, fragmentary view illustrating the connection between the selector valve and the packer subassembly illustrated in FIG. **8**. The packer assembly is connected to the lower end of the selector valve assembly **32** by a tubular coupler **176** threaded into the lower end of the outer housing member **146**. The coupling provides the passage **34**, which !s open to and in communication with the second . passage **163** in the inner housing member **147**. The coupling also provides a lateral port **177** interconnecting the inflate-deflate passage **156** and a passage **178** along which fluid flows to inflate and deflate the packers during such phases of the tool operation.

Referring now to FIG. **8**, the coupling member extends down along the tool through an upper inflatable packer **33**, which is formed of a tube of elastomeric material clamped at its upper end at **181** and at its lower end **182** to the exterior of the tubular coupler **176**. The upper inflatable packer **33** is connected to the inflate/deflate passage **178** by a lateral port **183** open to the interior thereof. Therefore, when the selector valve is in the inflate or deflate position, pressure communication is provided to the interior of the packer for inflation or deflation thereof. The tubular coupler is also provided with a second inflate/deflate passage **184** which is spaced from the inflate/deflate passage **178** and is also connected to the interior of the upper packer **33** through a port **186**. The inflate/deflate passage **184** is connected at its lower end to an additional inflate/deflate passage **187** formed of a tubular member which extends between the upper and lower packers. In FIG. **8**, only one of the packers is illustrate in order to simplify the drawings: however it should be understood that a lower packer similar to the upper packer **33** illustrated in FIG. **8** is usually provided at the lower end of the tool and is inflated and deflated through the inflate/deflate passage **187**.

The passage **34** is open to the zone between the two packers through a port **191**. A passage system **189** is also provided to bypass the packers and connect the portion of the well above the upper packer to the portion of the well below the lower packer, even when the zone between the packers is isolated from the remainder of the well. In order to simplify the drawing, the passage system **189** is only illustrated in the schematic FIGS. **9** through **14**.

Operation

FIGS. **9** through **14** schematically illustrate the sequence of operations of the tool when a well treatment is to be performed. In each instance, the corresponding condition of the J-lock cam assembly **29** and the weight indication are indicated by the weight scale **16**.

Referring now to FIGS. **9**, **9***a*, and **9***b*, the tool is schematically represented in its run-in condition. In such condition, the tool is lowered into the well by lowering the support tube **11** into the well with the tool secured on the end thereof. During the run-in, the drag valve assembly **27** is held in the open position by the frictional drag of the leaf springs **28** along the surface of the well. Consequently, the liquid being pumped down to the tool is vented to the environment through the drag valve **27**. Further, during the run-in, the time delay assembly **31** remains in its extended position and the follower projection **95** is positioned in the upper pocket **101**. Consequently, the selector valve port **169** is open to the inflate/deflate passage **156**. Since the internal pressure within the tool is equal to the surrounding pressure, the packers **33** remain deflated.

As the tool is lowered into the well, the weight indicated by the weight scale **16** is monitored by the operator and increases as the tool is lowered to greater depth. During the lowering of the tool the operator also monitors the depth of the tool indicated by the measuring device **17**, illustrated in FIG. **1**.

In many instances, a tube end locator (not shown, but known to those skilled in the art) is also provided at the upper end of the tool so that the operator can establish when the tool is at the lower end of the production tube and correct the depth measurement provided by the measuring device **17** to compensate for stretching the tube **11** and also any slippage which might occur. This permits the operator to accurately locate the tool at the strata which is to be treated.

As the tool approaches the position at the strata to be treated, the weight reading **16***a* on the weight scale **16** is logged by the operator. That weight reading will be less than the actual weight of the tool and the string being supported by the grippers **14** because of the frictional drag of the tube and the tool as they are moving down along the well surface.

Generally, the operator lowers the tool to a position a few feet below the position in which the treatment is to occur before stopping the tool. The operator then reverses the grippers and raises the tool to the location in which treatment is to occur. As the tool is being raised the few feet back to the treatment position, the operator also notes the weight indication **16*b*** under a raising condition, which is greater than the run-in weight **16*a***, again due to the frictional drag of the string.

Such raising movement causes the drag valve **27** to move down along the tool to the closed position illustrated in FIG. **10**. The operator will note that the previously-noted down-load **16*a*** indicated during run-in will increase, as indicated at **16*b*** in FIG. **10*b***, as the tool is raised a short distance back to the treatment position.

After the tool is properly positioned at the treatment location the rate of flow of the fluid to the tool is increased. This produces a sufficient pressure differential across the piston head **59** to move the piston down, closing the equalizing valve **26**. Since the equalizing valve **26** and the drag valve **27** are closed, the pressure within the tool increases, causing inflation of the packers **33**, as indicated in FIG. **10**.

The operator then increases the force exerted by the grippers to increase the tension in the tube **11** to verify that the packers have in fact been inflated. Since the packers lock the tool against movement along the well when they are inflated, increased tension will cause an increase in the weight reading indicated by the arrow **16*c*** beyond the up-load reading indicated at **16*b***.

In some instances, the tool may encounter obstacles during the run-in operation which cause the J-lock assembly and the selector valve to move to an inject position in which the follower projection is located within the pocket **102**. This does not present a problem if the tool is not extended after the tool is raised up a short distance back to the treatment position. The pressure within the tool causes extension of the selector valve due to its action against the area of the inner housing member **147**. This returns the selector valve to the extended position in which the follower projection **95** is in the pocket **101**.

Since the weight of the tool is not supported in that instance, and since the extension force produced by the tool pressure is relatively small, the pressure above the piston head **123** of the time delay assembly **31** remains below the pressure required to move the sleeve valve **134** against the action of the springs **136** so the large orifice assembly **146** remains open, permitting substantially free travel of the time delay valve assembly **31** to its extended position for proper inflation of the packers.

After the packers are properly inflated, as determined by the weight indication **16*c***, the load supported by the grippers **14** is reduced and the tool moves to a position illustrated in FIG. **11**, in which the selector valve assembly moves downwardly relative to the tool body causing the follower projection **95** to move along the path **103** into the pocket **102**, indicated in FIG. **11*a***. This permits the testing of the strata to determine if it will accept fluid. This movement of the selector valve isolates the inflate/deflate passage **156** so the packers **33** remain in their inflated condition and continue to isolate the zone of the well therebetween from the remaining zones of the well. A weight indication **16*d*** less than the run-in weight **16*a*** establishes that the packers remain inflated.

The movement of the upper portions of the tool in the downward direction tends to cause the drag valve to move upwardly to its upward limit position, as illustrated in FIG. **11**, but the downward movement of the selector valve positions the ports **87** so that they are closed by the lower housing assembly of the tool. Therefore, any liquid or other fluid pumped down the tube **11** into the tool is directed to the zone between the packers. The operator at this time determines whether or not the strata, which is isolated from the remainder of the well and which is to be treated, will accept fluid.

It should be noted that when the tool string is lowered to the position of FIG. **11**, the lower end of the piston member **58** engages a shoulder on the lower housing and the piston member is moved back to its upper position within the equalizer valve assembly. However, the equalizer valve remains closed because the port **64** is closed.

At the completion of the injecting testing operation, the rate of flow of the fluid down to the tool is reduced and the powered grippers **14** are operated to raise the upper portion of the tool relative to the lower portion in a sequence which positions the tool in the position for spotting the treatment fluid indicated in FIG. **12**. By increasing the tension to a value above the up-load **16*b*** the operator is assured that sufficient tension is present to extend the upper portion of the tool relative to the lower portion.

Substantially free travel is provided until the tool extends beyond the location indicated by the line **108**, since the initial portion of extension occurs while the damper piston head portion **123** and the sleeve valve **134** are moving along the lower cylinder portion **119**, which is sufficiently large to allow fluid to bypass the piston assembly.

When the position indicated by the line **108** is reached, the piston assembly moves into the upper cylinder portion **116** and continued upward movement of the piston assembly requires flow through the orifices. The rate of upward movement however, causes sufficient differential pressure to occur across the sleeve valve **134** to cause it to move against the action of the springs **136** to close the larger orifice assembly **126**. Thereafter, the only open path of flow past the piston is provided by the small orifice assembly **127**, which is sized to require at least about three minutes for the valve to move to a fully extended position. As soon as the load on the grippers increases, as indicated at **16*e*** in FIG. **12*b***, the operator is provided with an indication that the damping or time delay function is commenced. The operator then continues to raise the upper portion of the tool for a period of time less than two minutes to ensure that the selector valve does not fully extend.

During this upward movement of the tool, the follower projection **95** moves up along the cam surfaces along the path **106** and is positioned alongside of the island cam **107**. The operator then decreases the tension on the support tube **11** and causes the follower projection **95** to move down along the cam surface along the path **109** into the J-lock position at **99*g***. In such position, the port **169** in the selector valve is in alignment with the circulation port **35** in the lower tool housing. Such downward movement may also cause the drag valve **27** to open, as indicated in FIG. **12**. Also, the upper housing assembly of the equalizing valve 6 assembly **26** moves to its compressed position during this downward movement. A weight indication **16*d*** less than the run-in weight **16*a*** again confirms that the packers are still inflated.

The spotting operation is commenced by moving the selector valve **19**, illustrated in FIG. **1**, to connect the treatment liquid reservoir **22** to the pump **18** so that the treatment fluid is pumped down the support tube **11** to the tool and the inflation fluid is displaced from the tube through the port **35** and/or the ports **87**, both of which are open to the environment. This spotting operation functions to expel the inflation fluid from the tube **11** and to position the leading edge of the treatment fluid at the tool for subsequent injection.

The operator then operates the power grippers to increase the tension in the support tube **11** to raise the follower projection **95** out of the spotting pocket **99*g*** until it moves past the position indicated by the line **108** in FIG. **13*a*** along the path **111**. The fact that the tool has been raised into the damping zone above the position of **108** is again indicated by an increase in the weight to **16*f*** on the grippers. Here again, the tension is only maintained for less than two minutes of the three-minute time delay provided by the time delay assembly to ensure that the valve does not move back to the inflate/deflate position.

The load on the grippers is then decreased, causing the follower projection **95** to move down along the path **110** back to the lower pocket **102**. This positions the valve for injection, as illustrated in FIG. **13**. Again, a weight . reading **16*d*** less than the run-in weight **16*a*** establishes that the packers remain inflated. The treatment fluid is then pumped down to the tool and is injected into the strata between the two packers **33**.

At the completion of the injection phase of the operation, the operator shuts off the pump and increases the load on the grippers to a value **16*g*** greater than the up-load value indicated at **16*b*** to again move the follower projection **95** up along the cam surface **99** along the path **106**. When the damper again moves into the damping position, the tension is maintained on the support tube for more than three minutes, so the follower projection **95** moves back to the upper pocket **101**.

Once the selector valve reaches the deflate position, the inflate/deflate passage **156** is opened through the ports **63** and **64** and the pressure is equalized through the equalizing valve **26**. This causes the packers **33** to deflate. A decrease in weight reading from **16*f*** back to the pull-up weight **16*b*** establishes that the packers are deflated.

At this time, the tool can be moved to another location where treatment is required and the cycle can be repeated, or the tool can be raised up out of the well.

FIGS. **15** through **15*c*** illustrate a novel and improved method of producing an internal camming surface along the inside of a relatively long and relatively narrow tubular member. As a first step in the formation of the camming surface, a solid cylindrical mandrel **201** is selected having a diameter equal to the maximum diameter of the camming surfaces. The mandrel **201** is then machined along its outer surface to cut into the outer surface thereof the required camming surface structure. For example, in producing the J-lock cam assembly, a series of cam grooves **202** are cut into the outer surface of the mandrel **201**, as illustrated in FIG. **15*a***. Once the camming grooves have been cut into the outer surface of the mandrel **201**, the mandrel is inserted into the outer tube **203**. The mandrel is connected to the outer tubular sleeve **193** by button welds **204** which fill openings previously formed in the tubular sleeve **203**. Such button welds are appropriately placed to provide a connection between any island cam portions, such as the island portions **104** and **107**, and also to connect other portions of the mandrel to the sleeve. Thereafter, the central portion of the mandrel is bored out, as illustrated in FIG. **15*c*** to a diameter which exceeds the inner diameter of the cam grooves. In this way, external machining can be provided to produce intricate camming surfaces along the inside of a relatively narrow and relatively long tube.

With this invention, a treatment tool is provided which can be controlled with certainty from the well head by noting changes in the load on the power grippers as indicated by the weighing scale **16**. In each step of the operation, changes in the weight indicated by the scale **16** provide the operator with an indication that the previous portion of the cycle has been properly and successfully completed and that the tool is in proper condition for a subsequent operation. Because weights, and not distances, are utilized to control the operation of the tool, any slippage occurring in the depth measuring device **17** or stretching of the support tube **11** do not adversely affect the operation of the tool. Further, it is not necessary to rotate the tube to control the operation of the tool. Still further, it is not necessary to rely upon electronics or dropping balls to determine the condition of the tool and the simple weight scale **16** provides the operator with all of the information he needs to have concerning the operation of the tool through a complete cycle. Still further, with this invention a small diameter tool is provided that can fit a relatively small production tube and operate in a casing having a substantially greater diameter.

Although the preferred embodiment of this invention has been shown and described, it should be understood that various modifications and rearrangements of the parts may be resorted to without departing from the scope of the invention as disclosed and claimed herein.

What is claimed is:

1. A system for treating subterranean wells comprising an elongated treatment tool having inflatable packers, a support tube connected to one end of said tool operable to lower said tool from a well head into a well and to supply liquid to said tool, said tool providing valve means operable in response to changes in tension in said tube and without rotating said tube to sequentially:

(a) inflate said packers to isolate one portion of said well from the remaining portions thereof and to lock said tool against movement along said well;

(b) inject treatment fluid supplied to said tool through said support tube into said one portion of said well; and

(c) deflate said packers permitting further movement of said tool along said well.

2. A system as set forth in claim **1**, wherein said valve means is also operable in response to changes in tension in said tube and without rotating said tube to open said tool to permit discharge of liquid from said support tube into said other portions of said well after said packers are inflated allowing treatment liquid to flow along said tube to said tool for spotting said treatment liquid at said tool for subsequent injection into said one portion of said well.

3. A system as set forth in claim **2**, wherein said system includes weight measuring means permitting an operator at said well head to determine changes in tension in said support tube to control the operation of said valve means.

4. A system as set forth in claim **3**, wherein said valve means includes time delay means permitting an operator at said valve head to control said valve means for spotting said treatment liquid.

5. A valve for tools used in subterranean wells, comprising first and second elongated tubular housing members connected for telescoping movement relative to each other between an extended position and a compressed position, piston means in one of said housing members movable relative thereto between a first position and a second position, said valve being open between the interior of said housing and the exterior thereof when said housing members are in said extended position and said piston means is in said first position, said valve being closed when said housing means are in said compressed position or said piston means is in said second position, said valve being connected to a treatment tool having inflatable packer means, said valve operating to deflate said packer means when said housing members are in said extended position and said piston means is in said first position.

6. A valve as set forth in claim **5**, wherein said piston means moves to said second position in response to a predetermined rate of fluid flow to said valve.

7. A valve as set forth in claim **6**, wherein said movement of said housing members to said compressed position causes movement of said piston means to said first position.

8. A valve as set forth in claim **5**, wherein said housing members provide pressure balancing means preventing fluid pressure therein from moving said housing members to said extended position from said compressed position.

9. A valve for tools used in subterranean wells, comprising first and second elongated tubular housing wells, comprising first and second elongated tubular housing members connected for telescoping movement relative to each other between an extended position and a compressed position, piston means in one of said housing members movable relative thereto between a first position and a second position, said valve being open between the interior of said housing and the exterior thereof when said housing members are in said extended position and said piston means is in said first position, said valve being closed when said housing means are in said compressed position or said piston means is in said second position, said housing members providing pressure balancing means preventing fluid pressure therein from moving said housing members to said extended position from said compressed position.

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